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ABSTRACT

This publication is the course guide book for a one-semester, non-laboratory junior college course in biology. Included for each topic are lesson objectives, learning materials, and discussion ideas for seminar groups. Topics include the organization of life, heredity, reproduction, the meaning of biology to modern man, and homeostasis and cybernetics in animals, plants, and cells. (MH)

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BIOLOGY

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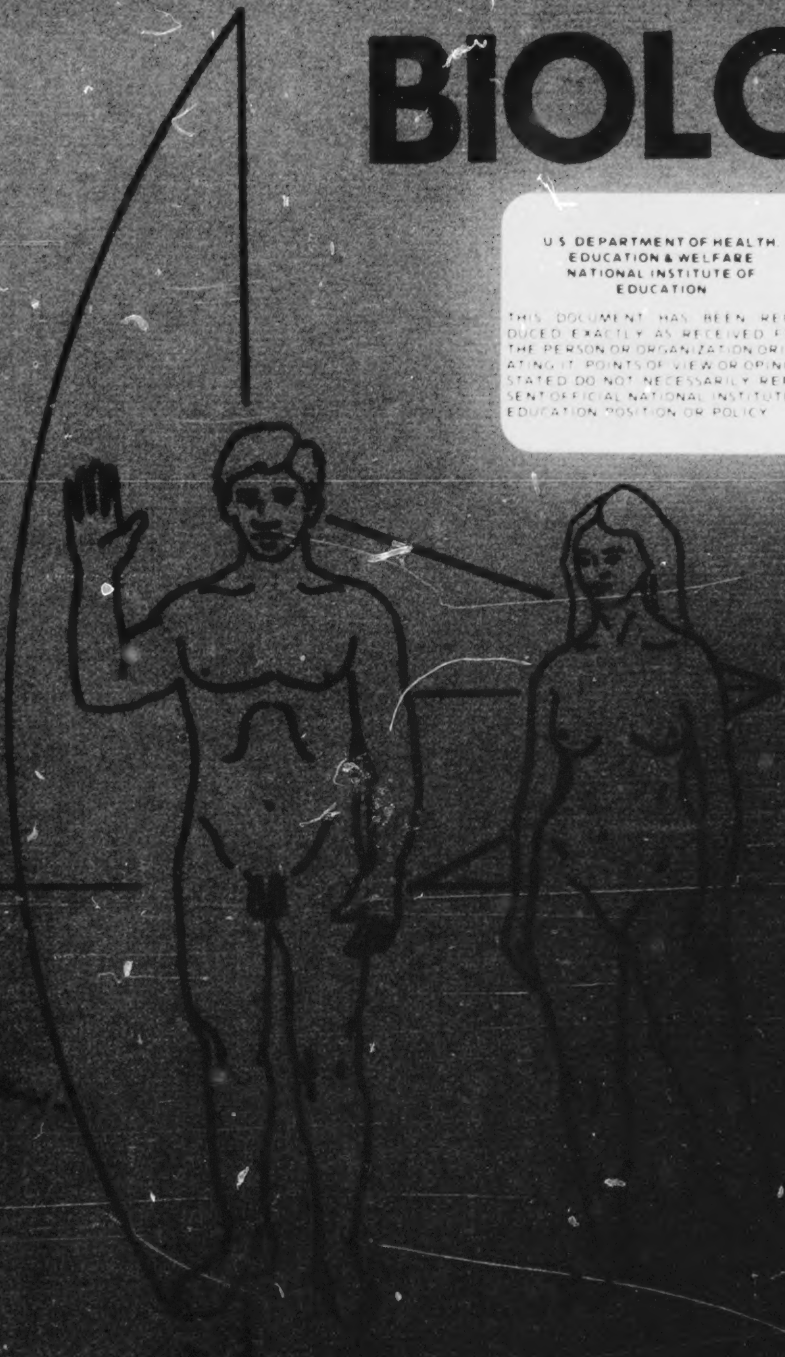

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GUIDE BOOK COVER

The cover design was taken from the plaque placed on the Pioneer 10 Spacecraft. Perhaps the message, explained below, is more an admission by man that he wants the record to state he WAS here. General Biology is a presentation of biology in concepts from [illegible] the history of life, the present and future implications. It is hoped that the student recognizes his position in the complex "web of life." The [illegible] student [illegible] also discover biological science as a source of possible answers to some of man's problems for survival and for a [illegible] his environment.

PLAQUE EXPLANATION

The Pioneer 10 spacecraft, [illegible] passes our solar system, [illegible] scientifically [illegible] engraved [illegible] where, and by whom [illegible]

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BIOLOGY 100-A

UNIT I INTRODUCTION

OBJECTIVES FOR UNIT I - INTRODUCTION

1. TO DEMONSTRATE THE CONCEPT OF "INDEPENDENT STUDY" AS A COMPONENT OF THIS COURSE.
2. TO INTRODUCE THE KINDS OF LEARNING RESOURCE MATERIALS THAT WILL BE UTILIZED IN THIS COURSE.
3. TO BEGIN A SERIES OF EXPERIENCES WHICH HOPEFULLY WILL LEAD YOU TO BECOME MORE "BIOLOGICALLY AWARE" THAN PERHAPS YOU ARE AT THIS POINT.
4. TO BECOME FAMILIAR WITH THE COMPOUND LIGHT MICROSCOPE, ITS WORKING PARTS AND PROCEEDURES FOR USE.
5. TO DEMONSTRATE COMPETENCE IN THE USE OF THE MICROSCOPE BY LOCATING AND IDENTIFYING PARTS OF A TYPICAL PLANT CELL.

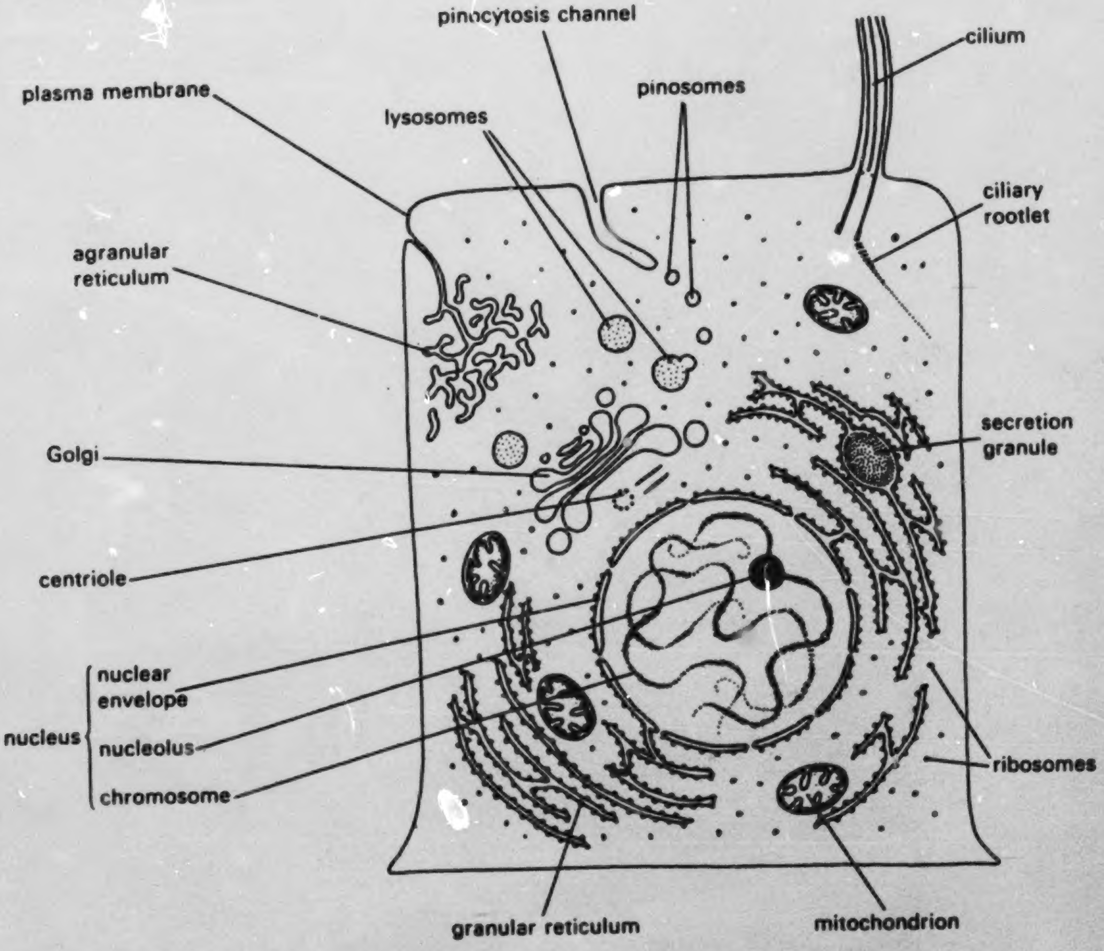
TOPICS FOR DISCUSSION IN SEMINAR GROUPS

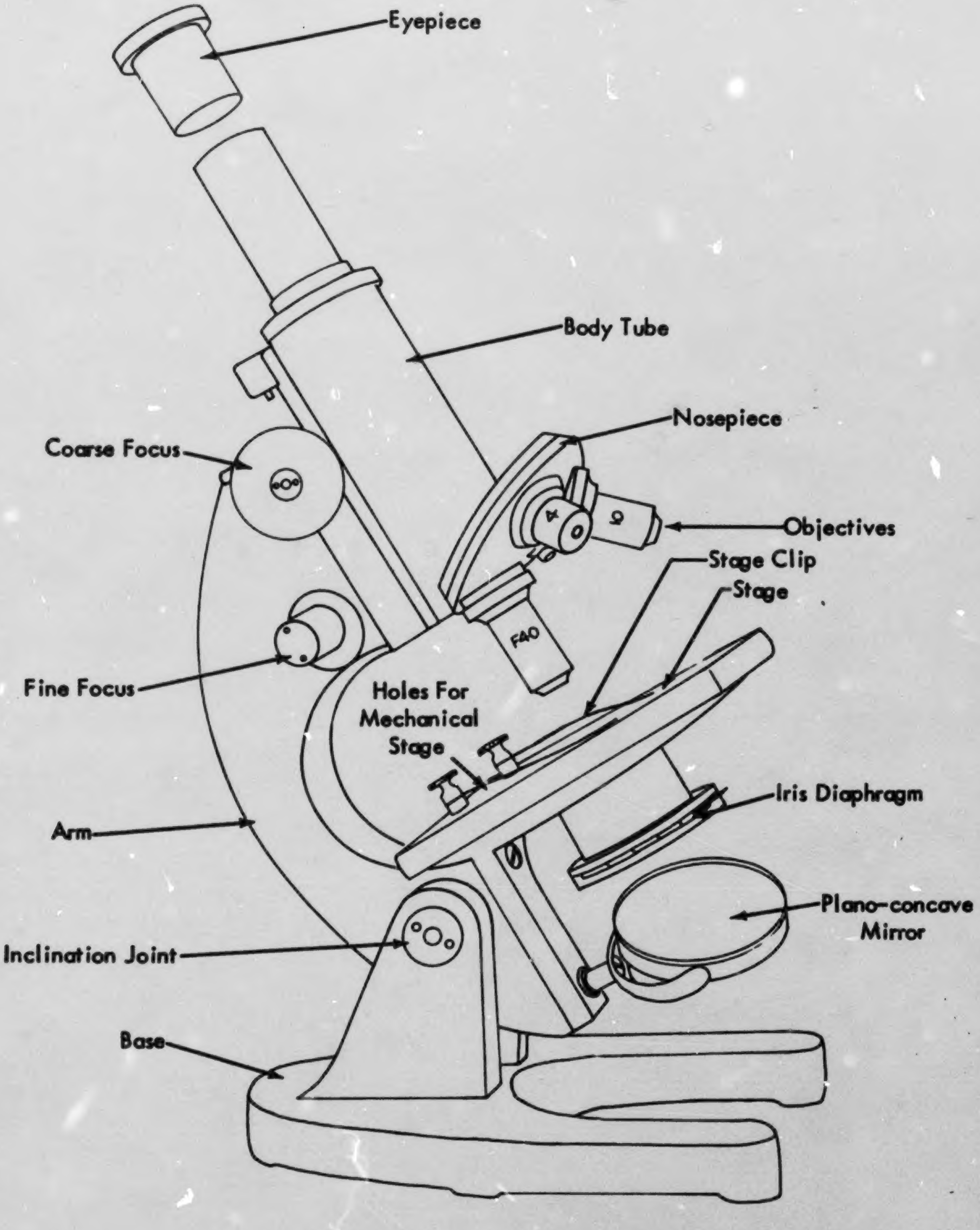
1. IN RELATINSHIP TO THE EDUCATIONAL PROGRAM OR MAJOR THAT YOU ARE PURSUING, WHAT SIGNIFICANCE DO YOU SEE "GENERAL BIOLOGY" HAVING?

2. WHAT SIGNIFICANCE DID THE INVENTION OF THE LIGHT MICROSCOPE HAVE FOR BIOLOGY? HOW WOULD YOU EXPECT PRESENT DAY TECHNOLOGY TO INFLUENCE BIOLOGY?

3. THE PURPOSE OF THIS SEGMENT OF YOUR COURSE IS TO GET YOU TO TALK. DISCUSS AND SUGGEST WAYS WITH YOUR INSTRUCTOR TO MAKE THE THIRTY MINUTES MORE PRODUCTIVE AND MEANINGFUL TO YOU AS A STUDENT. (REMEMBER THAT THE LAST THIRTY MINUTES OF THIS PERIOD IS FOR A WEEKLY QUIZ).

EUKARYOTIC CELL





Parts of the Compound Microscope.

BIOLOGY 100-A

UNIT II How Unique is Living Matter?

OBJECTIVES FOR UNIT II - HOW UNIQUE IS LIVING MATTER

UPON COMPLETION OF UNIT II THE STUDENT SHOULD BE ABLE TO DO THE FOLLOWING:

1. DEFINE "SCIENCE" AS IT RELATES TO SUPERNATURAL VS. NATURAL LAWS.
2. EXPLAIN WHAT IS MEANT BY THE PHRASE "THE "LAWS AND THE PARTICLES" AS IT RELATES TO LIVING MATTER.
3. NAME THREE CHARACTERISTICS WHICH IDENTIFY ANYTHING THAT CAN BE TERMED "LIVING".
4. DEFINE METABOLISM.
5. LIST FOUR CHARACTERISTICS OF MACROMOLECULES WHICH ENABLE THEM TO BE CLASSIFIED AS CONSTITUTING A LIVING SYSTEM.
6. EXPLAIN WHY BEHAVIORAL CHARACTERISTICS OF ATOMS ARE LARGELY DETERMINED BY THE OUTER SHELL ELECTRONS.
7. DIFFERENTIATE BETWEEN AN ATOM AND AN ION.
8. DISCUSS THE TWO METHODS WHEREBY CHEMICAL BONDS CAN BE FORMED BETWEEN ATOMS.
9. OF THE TWO METHODS WHICH IS MORE CHARACTERISTIC OF BONDING OCCURRING IN LIVING MATTER?
10. BE ABLE TO GIVE A REASON FOR THE SELECTION OF YOUR ANSWER IN #9 ABOVE.
11. LIST 4 ATOMS WHICH CONSTITUTE APPROXIMATELY 99% OF LIVING MATTER.
12. GIVE TWO REASONS WHY THE FOUR ATOMS ABOVE ARE DISTINCTLY "FITTED" FOR THEIR "ROLES" IN LIVING MATTER.
13. EXPLAIN WHY THE STATEMENT THAT "CARBON IS THE MOST FIT AMONG THE ELEMENTS TO SERVE AS THE MOLECULAR BACKBONE (STRUCTURAL BASIS) OF ALL LIVING MATTER" IS TRUE.
14. GIVE REASONS WHY WATER IS SO UNIQUELY FITTED TO SERVE A ROLE IN BIOLOGICAL SYSTEMS THAT NO OTHER MOLECULE COULD TAKE ITS PLACE.
15. DISTINGUISH BETWEEN ACIDS AND BASES; WHAT GIVES EACH IT'S SPECIFIC PROPERTIES. WHAT IS THE CONCEPT OF PH?

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. TWO CONTRASTING VIEWPOINTS OF LIFE'S OPERATIONAL PROCEEDURES.
   (A) THE ULTIMATE AIM OF BIOLOGY IS TO EXPLAIN LIFE IN TERMS OF PHYSICS AND CHEMISTRY.
   (B) LIFE PROCESSES GOVERNED BY A SUPERNATURAL BEING OR FORCE.

2. IS A LIVING FORM "UNIQUE" WHEN COMPARED TO A NON-LIVING FORM - SUBSTANTIATE YOUR ANSWER.

3. WHAT IS YOUR OPINION OF THE STATEMENT "RESEARCH ON THE CHARACTERISTICS OF THE ATOMS AND MOLECULES FOUND IN LIVING MATTER HAS LED TO THE CONCLUSION THAT LIFE ANYWHERE MOST PROBABLY IS DESIGNED ON A PATTERN SIMILAR TO THAT FOUND ON THIS PLANET." (I.E., A C-H-O, WATER SCHEME)

4. DO YOU CONSIDER MAN TO BE THE MOST "UNIQUE" FORM ON EARTH. DEFEND YOUR ANSWER.

UNIT II

Table I. The elements necessary for Life Comparing their Relative Abundance in the Universe, Earth's Crust, and the Human body. (Loewy and Siekevitz, Cell Structure Function, p. 29)

Category	Element	Chemical Symbol	Atomic Number	Relative Abundance (%)		
				Universe	Earth's Crust	Human Body
Major Constituents	Hydrogen	H	1	91	0.44	60
	Carbon	C	6	0.91	0.44	11
	Nitrogen	N	7	0.42	0.16	2.4
	Oxygen	O	8	0.057	62.6	26
Trace Elements	Sodium	Na	11	0.00012	2.6	0.7
	Magnesium	Mg	12	0.0023	1.8	0.01
	Phosphorus	P	15	0.00034	0.23	0.13
	Sulfur	S	16	0.0091	0.12	0.13
	Chlorine	Cl	17	0.00044	?	0.033
	Potassium	K	19	0.000018	1.4	0.037
	Calcium	Ca	20	0.00017	1.9	0.22
Ultratrace Elements	Boron	B	5			
	Silicon	Si	14	0.026	21.2	0.00091
	Vanadium	V	23			
	Manganese	Mn	25			
	Iron	Fe	26	0.047	1.9	0.00059
	Cobalt	Co	27			
	Copper	Cu	29			
	Zinc	Zn	30			
	Monybdenum	Mo	42			

The bioelements (those found in living life forms) fall into three groups according to their occurence in living organisms, the major constituents - accounting for about 99% of all elements found in living organisms, the trace elements - required by all organisms but in much lesser quantities, and the ultratrace elements many of which are not of universal occurence. Note that the relative abundances - occurrence in the universe, earth's curst, and the human body - do not show a general correlation.

Life and the Periodic Table

A characteristic property of living matter is that it is selective. It selects certain environments; it utilizes only certain molecules as food sources; it aggregates in particular organizations. An example of this selectivity is the preference for only certain elements from the large number of possible elements. Living organisms are made mostly of hydrogen, oxygen, carbon and nitrogen with the remaining elements constituting less than one percent of the total (Table I). From this, one can conclude that living matter preferentially selects for certain elements which are made available to it in the earth's crust and atmosphere.

To more fully appreciate this selectivity, a bit of background information may be desirable on the nature of chemical elements. It is an interesting property of the elements that they can be organized into a certain pattern and everywhere, the elements conform to this classification. A sound and useful classification of the elements, based on the atomic structure of each element, is found in the Periodic Table. (See Table II).

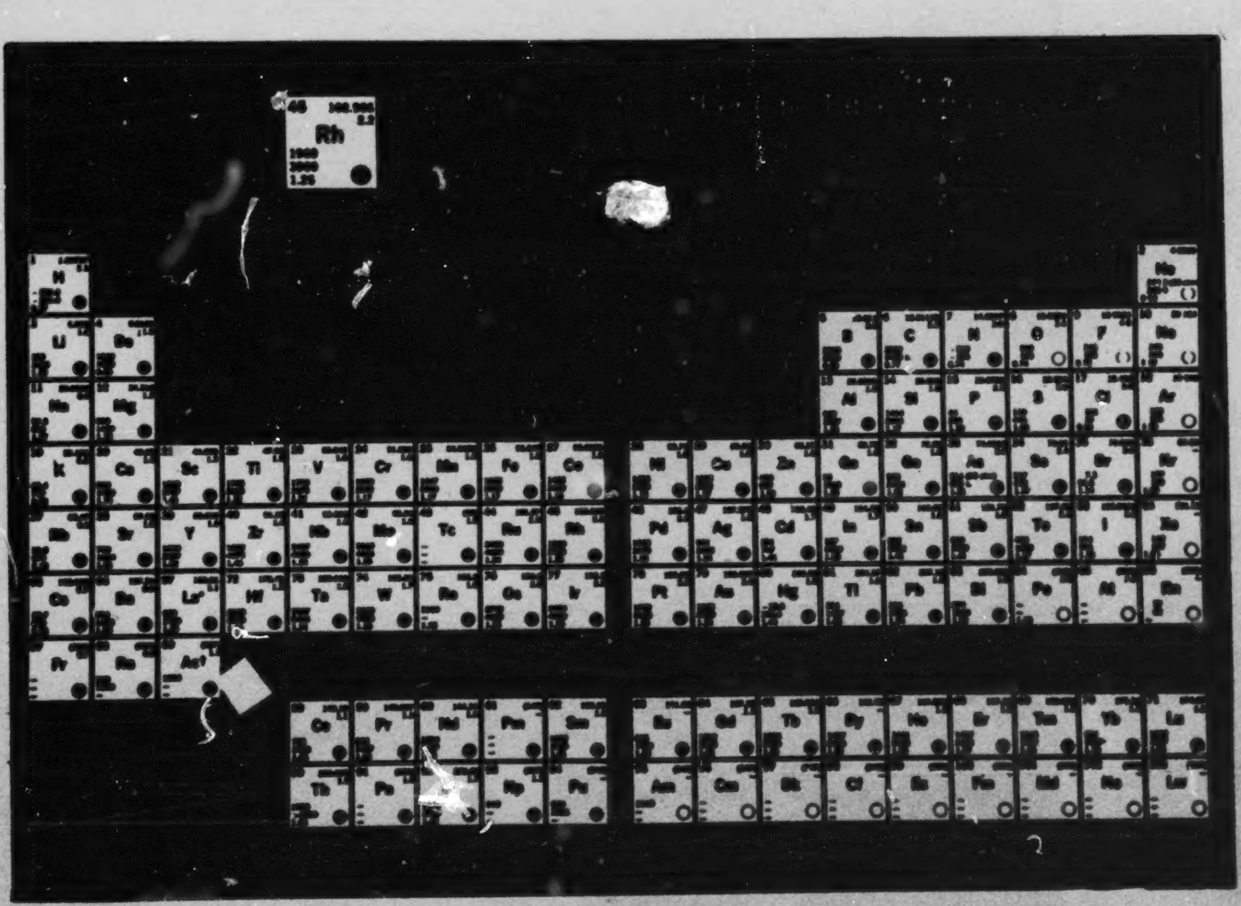


Table II

Inasmuch as our objective is to understand the natural laws involved in the interactions between certain atoms to form molecule we need concern ourselves only with the outer portion of the atoms, the electrons. A fundamental premise in atomic theory is that the chemical behavior of the atoms is a function of their peripheral (outermost) electrons only. The Periodic Chart is more understandable if we ignore the insides of the atom and consider the actions of the electrons in the outer region.

In the Periodic Table, all known elements are grouped accordin to chemical properties, that is those with similar chemical properties occur again and again with regular periodicity, hence the name, Periodic Table. Elements with similar properties are represented by the vertical columns of elements. For example, all of the elements in the column under hydrogen (chemical symbol H) have one outermost electron and display therefore, certai common properties. All elements listed under beryllium (Be) have two outermost electrons and show characteristics in common which are different from Group I. For each element, the atomic number is given above the symbol for the element. The atomic number describes the number of protons (plus charges in the atom, see Figure 1) in the atom and is always equal to the number of electron in that atom. Hence carbon, atomic number 6 has six (6) protons (6+) and six (6) electrons (6-). In moving from left to right across the chart, the elements are arranged in increasing order of protons, (hence, also electrons). The extreme right hand column (VIII) are located the Noble gases, the chemically "desired" state of each element in that row. Thus, chemically carbon, At. No. 6 would like to "look like" Neon (Ne) At. No. 10.

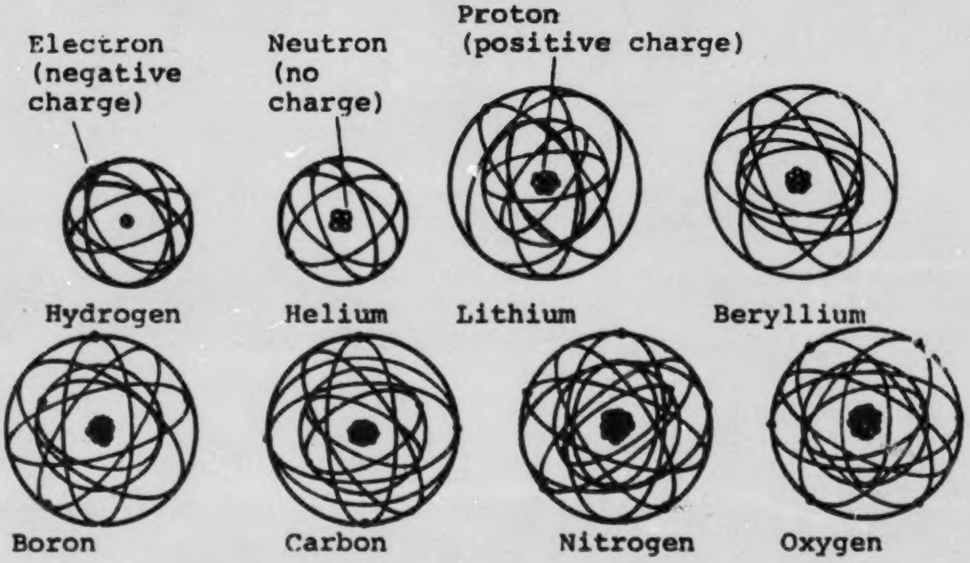


Fig. 1 Neutrons, protons and electrons in the configurations of atoms.

Compare the Periodic Table with Table I. Circle the major and trace elements (from Table I) in the Periodic Table to empasize their position in the Table. It is readily apparent that the elements found in living organisms tend to be the lighest elements. That in itself does not seem strange, for the lightest elements tend also to be the most abundant, on earth as elsewhere in the universe. However, when one compares the occurrence of the first three elements in the human body with their relative numbers on the earth - it is readily apparent that an argument from abundance is not the whole answer - for organisms can concentrate many times over these relatively rare elements. A study of Table I, comparing the incidence of the bioelements in the universe with their occurrence on this planet and in the human body, leads to the conclusion that these elements were selected for by nature on the basis of their essential properties rather than their availability. It is remarkable in this respect that living matter is very much like the cosmos as a whole. The stars as well as the interstellar matter are composed mostly of light elements. Our earth is but a "mineral ash" of heavy elements that remained after the light elements disappeared into space owing to the weak gravitational pull of tiny earth.

HOW MUCH ARE YOU WORTH?

Nothing escapes the inexorable spiral of inflation. It stands to reason that the chemicals in the human body must be worth more with each passing year.

At present, the approximate value of all chemicals in the average adult human body is $3.50, reports Donald T. Forman, assistant prof. of biochemistry.

Northwestern University Medical School, and head of the chemical laboratory, at the Northwestern-affiliated Evanston hospital. This new evaluation represents a 257% increase over the 1936 estimated value for the same chemicals of 98¢.

In percentage terms, Forman says the adult body is composed of 65% oxygen, 18% carbon, 10% hydrogen, 3% nitrogen, 1 1/2% calcium, 1% phosphorous and 1 1/2% of other elements, including traces of gold and silver.

* *

Review of Atomic Structure. (If more information is required, consult a textbook, i. e., Biology, H. Curtis, pp. 94ff)

(Fill in the blanks as directed. Answers are given in Appendix I)

1. According to current concepts, all matter in the physical universe is composed of particles. Although approximately 36 different particles have been identified by physicists, three are particularly important to biological systems. These are neutrons, protons and electrons. The particles can be arranged into units called atoms. There are 104 different kinds of atoms presently known. Each different kind of atom is called an element. Hence there are ___________ elements known today.

2. These 104 elements differ in the organization of their 3 basic particles: protons, neutrons and electrons. One model of atomic structure places protons and neutrons in the nucleus of the atom while electrons are found in shells (or orbits) at varying distances from the nucleus. Any two elements are different in the organization of their ________________, ________________, ______________.

3. Protons and neutrons both have weight. Each proton and each neutron is arbitrarily given an atomic mass unit (a.m.u.) of one (1). The combined weight of all protons and neutrons in an element is the atomic weight of that element. The number of protons in a nucleus gives the atomic number of that element. On the lines below indicate the atomic weight and atomic number given the information to the left.

	Atomic Weight (a.m.u.)	Atomic Number
A. 6 protons, 6 neutrons		
B. 5 protons, 6 neutrons		
C. 11 protons, 12 neutrons		
D. 30 protons, 35 neutrons		

4. Neutrons do not contribute to the chemical properties of an element. However, they do play a role in general stability of the atom. The number of neutrons in a nucleus may vary. The atomic weight, given as a fraction in the Periodic Table, is an average value for that element, the difference being due to the variation in neutron numbers. The general designation, isotope, is given to any atom in which the atomic weight differs from the norm as a result of the presence of fewer or more neutrons. A radioactive isotope of carbon commonly used in biological research is Carbon -14. Normal carbon is Carbon -12. C^{14} has therefore (a) ______________ protons and (b) ____________ neutrons.

5. Electrons have relatively no weight but do carry an electric charge. Each electron (abbreviated e$^-$) has a charge of minus 1 (-1). Protons have an electric charge as well as weight. Each proton has a charge of plus 1 (+1). A typical atom has an equal number of protons and electrons and is therefore electrically neutral. If an atom has an atomic number of 13, ______________ electrons would be contained in shells around the nucleus.

6. If the number of protons and elctrons in an atom is not the same, the atom is electrically unbalanced and is called an ion. The extra number of +'s or -'s in an ion is the ionic charge. An atom with 4 protons and 6 electrons would have an ionic charge of -2. Given the information on the left, fill in the blanks with the desired information.

		Ionic Charge
A.	9 protons, 8 electrons	______________
B.	3 protons, 4 electrons	______________
C.	14 protons, 17 electrons	______________
D.	19 protons, 15 electrons	______________

7. Although protons and neutrons seem to be randomly distributed in the nucleus, electrons occur in specific patterns about the nucleus. The shell closest to the nucleus will hold only 2 electrons. The next shell out will hold 8 electrons.

A. How many electrons are around a nucleus when both shells are filled?________.

B. How many protons would you expect in the nucleus?_______.

8. An atom is most stable when the outermost shell is filled or eight (8) are positioned in that shell. The maximum permissible number in each shell (from nucleus outward) is 2, 8, 18, 32. Indicate the electron distribution of the following elements and tell whether each would be reactive chemically (the equivalent of not stable):

Atomic number	Electron Distribution				Chemical Reactivity (circle one)	
5	____	______	____	____	Yes	No
8	____	______	____	____	Yes	No
10	____	______	____	____	Yes	No
18	____	______	____	____	Yes	No
20	____	______	____	____	Yes	No

9. Thus, chemical reactivity as well as the chemical properties of an atom are determined by the number of electrons in the outer shell. Nitrogen (N_2) with (a) ______ e^- in the outer shell has different chemical properties than oxygen (O_2) which has (b) ________ e^- occuring in its last shell.

10. Elements seemingly demonstrate a "desire" to have a full outer shell. Full outer shells are obtained through gaining or losing electrons. Hydrogen (H_2), with one (1) electron in its outer shell requires the addition of one more electron to obtain chemical stability (full outer shell). Oxygen, with an atomic number of eight (8), would require _____ e^- for chemical stability.

11. Outer shell electrons are gained or lost in a process called chemical bonding. The most direct aspect of chemical structure involved in bonding is:

a. the nucleus;
b. the protons;
c. the total number of electrons possessed by an element;
d. the outer shell electrons only.

Review of Atomic Structure - Answer Sheet.

1. 104

2. protons, neutrons, electrons

3.

	Atomic weight	Atomic number
A.	12	6
B.	11	5
C.	23	11
D.	65	30

4. (a) 6 (b) 8

5. 13

6. A. +1
   B. -1
   C. -3
   D. +4

7. A. 10
   B. 10

8.

(1)	2	3	0	0	yes
(2)	2	6	0	0	yes
(3)	2	8	0	0	no
(4)	2	8	8	0	no
(5)	2	8	8	2	yes

9. (a) 5 (b) 6

10. 2

11. (d)

BIOLOGY 100-A

UNIT III A "MODEL" FOR LIFE

OBJECTIVES FOR UNIT III - A "MODEL" FOR LIFE

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. BE AWARE OF THE FACT THAT MODELS IN BIOLOGY ARE REPRESENTATIONS OF REAL LIFE PHENONEMA AND ARE SUBJECT TO CHANGE DEPENDING UPON THE REFINEMENT OF KNOWLEDGE.

2. UNDERSTAND THE CONCEPT IN BIOLOGY OF ORGANIZATION HIERARCHY.

3. BE AWARE OF THE FACT THAT LIFE WITH ITS FULL SET OF ATTRIBUTES FIRST EMERGES AT THE CELL LEVEL.

4. BE ABLE TO LIST TWO REASONS WHY PROTEIN MOLECULES ARE SO IMPORTANT TO LIVING SYSTEMS.

5. BE ABLE TO EXPLAIN THE CHEMICAL STRUCTURE OF AN AMINO ACID (WHAT MAKES IT UP).

6. BE ABLE TO DETERMINE HOW AMINO ACIDS ARE PUT TOGETHER TO FORM COMPLEX PROTEINS AND HOW COMPLEX PROTEINS ARE BROKEN DOWN TO PRODUCE AMINO ACIDS.

7. UNDERSTAND THE TWO MAJOR FUNCTIONS OF PROTEIN MOLECULES IN BIOLOGICAL SYSTEMS.
   (1) STRUCTURAL
   (2) REGULATOR FUNCTION

8. BE ABLE TO EXPLAIN WHAT ENZYMES DO IN SERVING AS REGULATORS FOR CHEMICAL ACTIVITY WITHIN THE CELL. (AT LEAST THREE IDEAS ARE USEFUL HERE).

9. LIST TWO CHARACTERISTICS OF ENZYMES WHICH LIMIT THEIR USEFULNESS IN BIOLOGICAL SYSTEMS.

10. BE ABLE TO IDENTIFY THE SINGLE MOST FUNDAMENTAL CHEMICAL REACTION ON THIS PLANET.

11. BE ABLE TO UNDERSTAND BASIC FACETS OF CARBOHYDRATE METABOLISM:
    (1) USE OF CARBOHYDRATES
    (2) HOW COMPLEX CARBOHYDRATES ARE FORMED FROM SIMPLE ONES
    (3) ROLE OF GLUCOSE IN CARBOHYDRATE METABOLISM

12. BE ABLE TO IDENTIFY THE FUNCTIONS OF FATS IN BIOLOGICAL SYSTEMS.

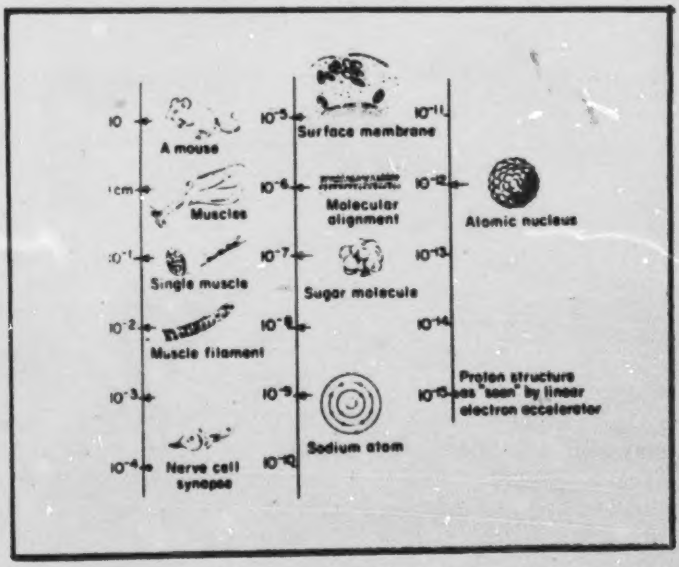
13. BE ABLE TO IDENTIFY THE FUNCTIONS OF A FOURTH GROUP OF BIOLOGICALLY IMPORTANT MACROMOLECULES; THE NUCLEIC ACIDS.

Topics for Discussion in Seminar Groups

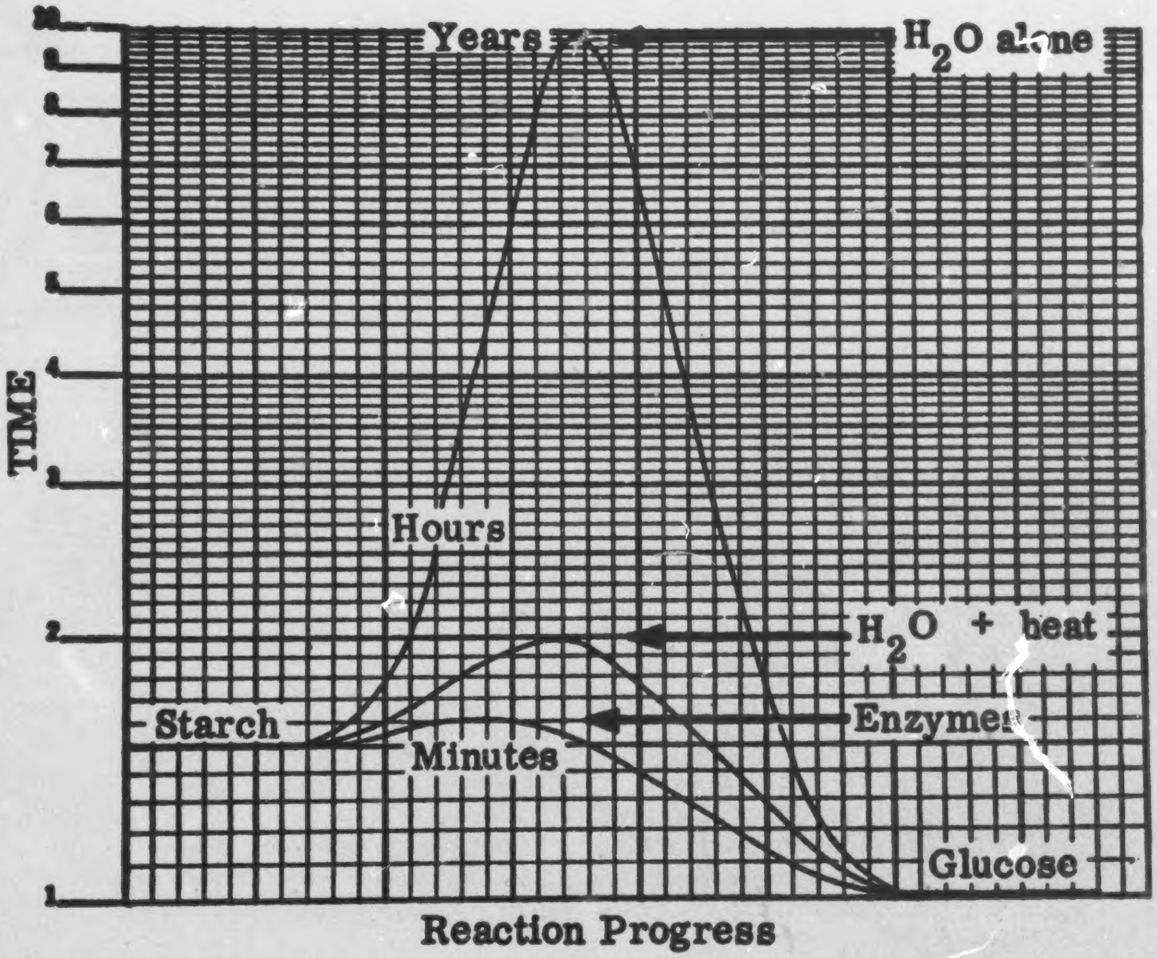
1. THE BIOLOGIST'S TEST TUBE OF INTERACTING CHEMICALS - A SUFFICIENT MODEL FOR LIFE?
2. THE SIGNIFICANCE (IMPORTANCE) OF A BIOLOGICAL HIERARCHY (ROLE IN ENVIRONMENTAL CONCERNS OF TODAY, FOR INSTANCE).
3. SIMILAR AND DISSIMILAR ASPECTS OF CARBOHYDRATE, FAT, AND PROTEIN METABOLISM.

UNIT III

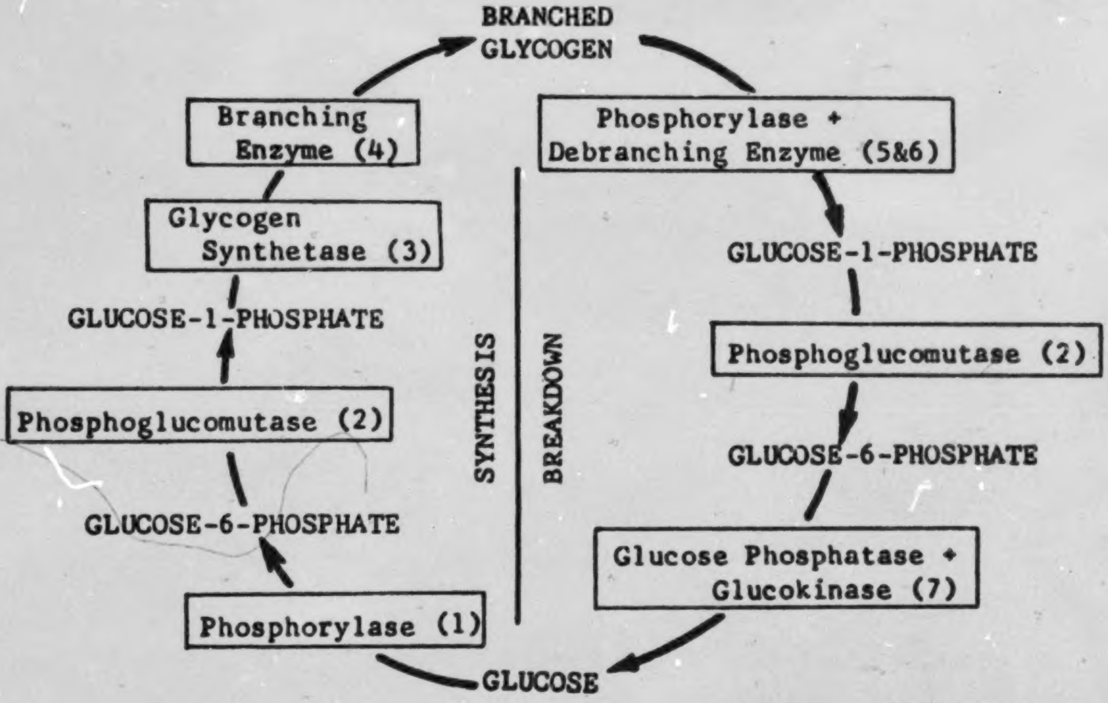
Table I. Major Organic Molecules in Living Matter.		
General Class	Molecule Size	Common Examples
Protein	Macromolecular	Hair, silk, skin, feathers, muscle, wool
Carbohydrate	Small to macro-molecular	Starch, sugar, cotton, wood
Fat	Small	Olive oil, butterfat, oleo, Crisco
Nucleic acids	Macromolecular	No common examples



The Concept of Integrative Levels - each leve of organization possesses unique properties which do not "a priori" predict the behavior of succeeding levels. (From The Strategy of Life by Cliffor Grobstein; W. H. Freeman & Co., San Francisco; 1964).



"Heat is Time" - Enzymes reduce time by lowering the amount of heat required to effect a chemical reaction. (The time scale in this diagram has been somewhat distorted.)



How important are enzymes? Metabolism in living matter requires specific enzymes; if any of these are missing, serious disease may result. The breakdown and synthesis of glycogen is shown here. The enzymes needed are indicated with a box. The numbers included correspond to the diseases listed in the following table.

Table II. Glycogen Deposition (storage) Diseases and their Related Enzyme Defects.

ANDERSEN'S DISEASE (Enzyme 4) - storage of abnormal glycogen molecules (unusually long branches) in liver and probably other organs.
FORBES' DISEASE (Enzyme 6) - storage of abnormal glycogen molecules (unusually short branches) in liver, heart, and muscle.
von GIERKE'S DISEASE (Enzyme 7) - abnormally large amounts of glycogen molecules (normal branching) in liver and kidney.
HERS' DISEASE (Enzyme 5) - abnormally large amounts of glycogen molecules (normal branching) in liver only.
McARDLE-SCHMID-PEARSON DISEASE (Enzyme 5) - abnormally large amounts of glycogen molecules (normal branching) stored in muscle.
POMPE'S DISEASE (Not certain which enzyme(s) lacking) - abnormally large amounts of glycogen molecules (normal branching) stored throughout the body.

Table III. Some Other Enzyme Related Disorders

Below is a partial list of disorders that are the result of metabolic defects. The metabolic defects occur when an appropriate enzyme (or set of enzymes) is lacking or, as in some vitamin deficiency diseases, the enzyme is present but is not active, the vitamin being necessary to make the enzymes active.

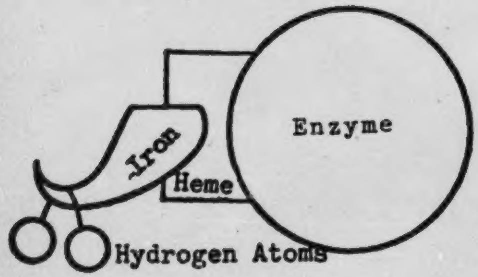
ALBINISM - little or no pigment in skin, hair, or eyes.
ALKAPTONURIA - homogentisic acid excreted in urine; arthritis.
AMAUROTIC IDIOCY - blindness, physical and mental impairment, death in infancy, childhood or adolescence.
CYSTINURIA - excretion of abnormally large amounts of cystine, lysine, arginine, and ornithine (all are amino acids) in urine.
DIABETES MILLITUS - low glucose tolerance.
GALACTOSEMIA - galactose (a simple sugar) not converted to glucose.
GAUCHER'S DISEASE - accumulation of lipids (fatty substances) and storage of cerebrosides in certain cells.
GOUT - abnormal uric acid metabolism; uric acid crystals accumulate around joints - preferentially the joints of the extremities.
HYPOGLYCEMIA - low blood sugar, mental retardation.
PHENYLKETONURIA - phenylpyruvic acid in urine; feeblemindedness.
TYROSINOSIS - abnormally large amounts of tyrosine (an amino acid) in urine.

Some Factors Effecting Enzymes - A Reading - Unit III

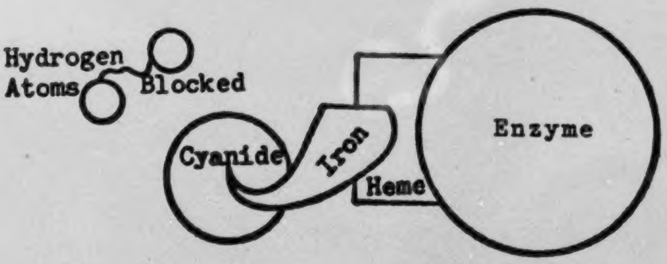
Enzymes are globular proteins. This means that the amino acid chains are woven into complicated patterns, held together in very delicate fashion, hence they are very fragile.

Heat is very hard on proteins. Molecules vibrate as a result of heat. The higher the temperature, the harder they vibrate. It doesn't take much vibration to shake loose the complicated structure of a globular protein. And not much heat is required to inactivate a protein. A hot summer day is enough. An internal body temperature of 105°F. or above is sufficient to seriously damage proteins. This is the reason why prolonged high fever accompanying certain illnesses is serious and can be lethal.

Other conditions also affect the enzyme's delicate structure. Small quantities of various chemicals can destory them. It is thought that most chemical poisons work in this way. Cyanide gas is known to destroy an important enzyme, the heme enzyme (iron-containing), important in energy-producing processes in living matter. Heme enzymes are present in small quantities, consequently just a few whiffs of cyanide gas are enough to ruin most of them. In a matter of minutes, the cells die of asphyxiation since they can no longer obtain energy.



Active Heme-Enzyme



Poisoned Heme-Enzyme

Chloroform blocks certain enzymes in the nervous system and was widely used as an early anesthetic. Mercury and lead poisoning affect certain enzymes in the kidney as well as the nervous system. Beryllium, a comparatively rare metal used to coat the inside of fluorescent tubes is another enzyme poison. The presence of this metal in fluorescent tubes is a special danger if one is accidentally cut with a broken fluorescent tube and some of the beryllium enters his blood.

Some enzymes require activators before they can function. The most important group of activators are the co-enzymes of which the vitamins rank first. Especially is this true for the B-vitamin group. If they are absent, co-enzymes are missing and important enzyme-controlled reactions slow up. The result can be illness or death (i.e., pellagra, beriberi, pernicious anemia). Vitamin A is involved in the chemical reactions in the eye; Vitamin D, for proper formation of bones; Vitamin K for proper clotting of blood and so on. In general, living matter can manufacture for itself those chemicals needed to carry on its activities. Plants and microorganisms in particular have no difficulty here. Animal matter is less versatile. Particularly is this true with vitamins and complex animal (i.e., man) require that the vitamins be provided in the diet. Proper diet is, therefore, of extreme importance in supplying these essential co-factors, the vitamins. To insure an adequate supply, many processed foods today have included the vitamins during manufacure. (Read what all is included in "Wheaties" sometime).

The point of all this is that living matter depends entirely upon the working of various enzymes. If anything interferes with those workings, living matter becomes dead matter. Conditions that inactivate enzymes, therefore, will eventually kill. (pollution??)

BIOLOGY 100-A

UNIT IV THE ORGANIZATION OF LIFE - PART I

OBJECTIVES FOR UNIT IV - THE ORGANIZATION OF LIFE - PART I

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. EXPRESS THE RELATIONSHIP BETWEEN THE 2ND LAW OF THERMODYNAMICS AND THE LIVING BIOLOGICAL SYSTEM.
2. DEFINE THE TERM ENTROPY - WHAT IS ITS RELATIONSHIP TO THE TERM "ENERGY"?
3. UNDERSTAND THE SIGNIFICANCE OF THE TERM "TIMES'S ARROW" - (WHAT DOES IT MEAN?)
4. EXPLAIN HOW "METABOLISM" ENABLES THE LIVING ORGANISM TO MOMENTARILY EVADE THE 2ND LAW OF THERMODYNAMICS.
5. DISTINGUISH BETWEEN THE TERMS HETEROTROPH & AUTOTROPH.
6. EXPLAIN THE PHRASE "ELECTRONS ARE ENERGY".
7. RELATE THE ROLE OF PHOTOSYNTHESIS TO THE "ELECTRON CYCLE" IN LIVING MATTER.
8. DISCUSS THE ROLE OF ATP IN BIOLOGICAL SYSTEM'S USE OF ENERGY.
    (A) WHAT IS THE SIGNIFICANCE OF THE ADP ATP EQUATION.
9. BE ABLE TO COMPARE ANAEROBIC AND AEROBIC RESPIRATION.
10. DEFINE GLYCOLYSIS AS A PHASE OF AEROBIC RESPIRATION.
11. DISCUSS THE RELATIONSHIP OF THE "KREB'S CYCLE" TO AEROBIC RESPIRATION.
12. BE ABLE TO WRITE AN EQUATION FOR AEROBIC RESPIRATION INVOLVING GLYCOLYSIS AND KREB'S CYCLE ASPECTS.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. WHAT IS YOUR EVALUATION OF THE STATEMENT "BIOLOGICAL FUNCTION IS VERY MUCH CONCERNED WITH USING ENERGY TO CREATE ORGANIZATION" (DOES THIS DETRACT FROM YOUR MEANING OF LIFE - DOES IT ENHANCE THE MEANING OF LIFE?)

2. THE BASES FOR CHARACTERIZING AEROBIC RESPIRATION AS THE "MODERN WAY" OF OBTAINING ENERGY. (CONVERSELY, WHY ANAEROBIC RESPIRATION AS THE "EARLY WAY" OF OBTAINING ENERGY.)

3. DO YOU AGREE WITH THE IDEA OF ENTROPIC DOOM? WHAT DOES IT HAVE TO DO WITH NATURE'S WAY OF DOING THINGS?

Table I. Some implications of the Second Law as it applies to biology.

1. All real processes are irreversible, going from high orderliness (low entropy) to low orderliness (high entropy).
2. If the temperature of a system is held constant, the free energy in the system will decrease unless energy is added from the outside.
3. The Second Law points the direction in time but does not tell when or how fast events will go.
4. Most biological energy transformations are the result of an energy redistribution between molecules following chemical reactions.
5. Biological function is mainly concerned with using energy to create organization.

Time's Arrow and Life - toward entropic doom - Unit IV

The universe may be eternal but nothing else is! No one can construct a clock that once wound, will go on forever. Sooner or later it must stop, even if it suffers no wear, unless energy continues to be fed into it. All systems left to themselves tend toward a state of lower activity and hence increasing disorganization. If we have two comparable systems, the less active and more disorganized one is older. This is called the "arrow of time"; it points in the direction of increasing entropy as the physicist calls it; more simply it can be interpreted as meaning uniform distribution, equipartition, of energy. Once energy has been uniformly distributed between the parts of the system, there can be no further flow of it between them and all activity must cease. The clock has run down.

In a mechanical or for that matter, a chemical system, this condition is reached when all energy in the system has been transformed into heat and a uniform temperature exists throughout; in other words, when each component molecule has an equal share of energy. This represents the ultimate degradation of energy variously termed "heat death", or more poetically, "entropic doom." The principle of "entropic doom" is enshrined in the Second Law of Thermodynamics or "The Second Law" for short. At one time, much thought was expended on the supposed eventual running down of the universe through increasing entropy. Yet the universe is obviously "alive and kicking" and it must have existed in some form or other for some time, now. A condition so frequently overlooked is that nature does not, many times, consider that the shortest distance between two points is a straight line. Things do not always happen this way in nature. Cyclic processes are most generally the rule. To take an example, the geological cycle: granite decays to sand, clay and mud, and that in turn is compacted into sedimentary rock which is gradually metamorphosed by pressure, heat and chemical reactions back into granite. Small increments of energy supplied to the system seemingly keep it eternal.

The universe is not alone in defying the Second Law. So does any living organism, from the smallest bacterium onwards. It may be argued by some that life does not really defy the Second Law for a non-living system, too, could be kept going if energy were supplied it from the outside, as it is to an organism in the form of food, light and heat. But the special point here is that living matter obtains energy by itself without any external agency, which, of course, a non-living system cannot do. The most ingenious computer built will follow truthfully the "arrow of time" to standstill and decay.

Life defies the "arrow of time" without intervention of external agencies, even on an individual scale. It is a clockwork that not only keeps rewinding itself but is capable of repairing the wear and damage it has suffered and even of improving itself. In the vast scale of evolutionary time, life shows a steady evolution in complexity, diversity and efficiency. Living matter appears to obey what Teilhard de Chardin has called the "law of complexification".

A living system, is characterized by a continuing drive toward a highly regular uniform structural organization. This last statement points to an intriguing paradox of nature: a very high degree of structural organization demands the continued input of a great deal of energy and a high degree of organization must be present in the organism or cell to be able to make use of the energy. In other words energy is required to maintain high order and high order is necessary to extract energy. A clue to the paradox is contained in the fact that chemical cycles are basic to biology. Hence small increments of energy can sustain highly organized life systems.

The problemmstill remains - "how does energy drive life?". This is one of the most basic problems of biology. A solution has been proposed which builds as its model a so-called "Electron Cycle". In our prior discussions, much has been made of bond energy which transferred from molecule to molecule through a series of intermediate reactions ultimately performs biological work. It is also understood that chemical bonding is essentially a play between interacting electrons. Hence, by deduction, it is fair to say that energy contained in the bonds of molecules is fundamentally "electron energy", and that active and mobile energy, on the molecular level is nothing more than electron activity. Life than is essentially built on the transformations of energy via electrons.

Life is allowed to defy the Second Law only for a limited time, for as the individual nears the end of his alloted span of life, his course is bent more and more in the direction of the arrow. The organism is progressively disorganized and ends up as any non-living system, with "entropic doom" the predictable fate of all. This concept is another of those fundamental to biology, for living matter becomes dead matter when the balance of organization is deranged beyond certain limits.

What distinguished living from non-living matter is organization. In these terms an organism may be characterized as an enclosed, highly specialized chemical organization in selective interaction with its environment, by means of which its specialized character is being constantly renewed. As long as the sun continues to be its benefactor, a momentary diversion of time's arrow can be realized.

ATP - "the most lifelike molecule" (J. B. S. Haldane) - Unit IV

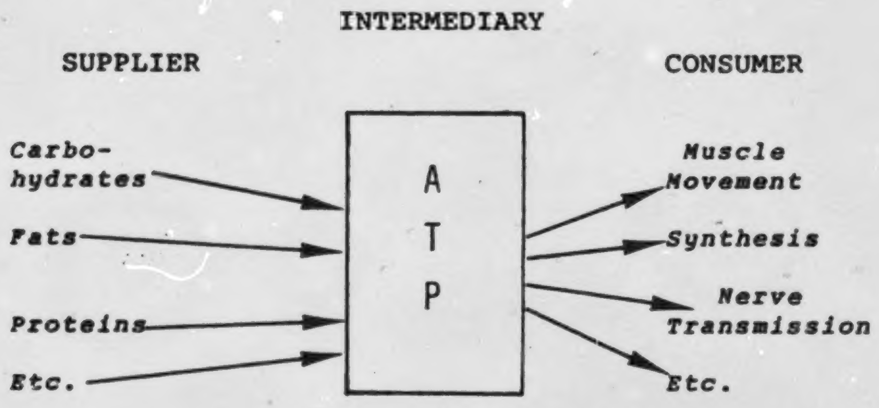
A distinctive feature of living matter is its ability to regulate the flow of energy through itself. All of living matter, whether it be animal, plant or microbial, utilized the same fundamental molecular principles and mechanisms in their energy-transforming activities. The energy-transforming activities in living matter may best be visualized in terms of a flow of c chemical energy from foodstuff molecules to those energy-requiring processes which are necessary for the function and survival of living cells (i.e., osmotic, mechanical, chemical or electrical work).

The energy of the food molecule is extracted by living matter, not in the form of heat, but rather as chemical energy. It is now quite certain that cellular energy is conserved in the compound adenosine triphosphate which has been known universally to all biologists for over 20 years by its initials-ATP. ATP is the carrier of chemical energy from the energy-yielding food molecules to those processes or reactions of living matter which require that energy be supplied to them.

Energy from foodstuff molecules is contained in the chemical bonds of the food. As energy was "locked" into the chemical bonds during the synthesis of the food molecule, so this energy is released as the food molecule is degraded in living matter.

Foodstuff molecules may be proteins, carbohydrates or fats as well as some relatively unorthodox substances such as alcohol. Any or all of these can provide the energy for the processes for which living matter requires energy. Considered from the standpoint of engineering this is no mean feat for living matter may be compared tb a machine that can act as many things while burning coal, gas or oil indifferently. A special fuel is not needed for each function nor does each fuel (food) produce a different product. It is as if we could burn wood, coal or turpentine as well as gasoline in our automobiles with equal efficiency.

Such versatility could hardly be achieved except by interposing a mediator between the many fuels and the users of power. The burning of fuels does not directly drive the various energy-requiring processes but is conducted in such a way so as to produce a universal product from any fuel source. The intermediary is ATP.



ATP - the universal currency in the biological world.

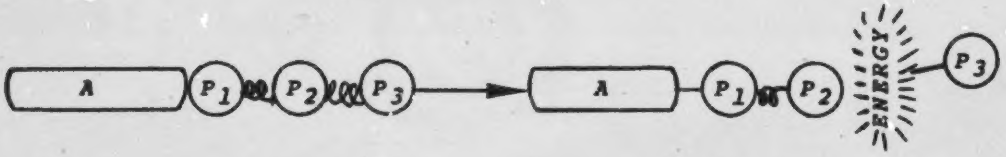
ATP is a "magic" word in the biological world. Just as money is necessary in the economic world, ATP is the currency used in the biological world. Generally speaking, nothing gets done inside living matter unless ATP is available.

The chemical structure of ATP is comprised of three kinds of building blocks. First, there is a carbon-nitrogen double ring called adenine. Attached to this is a molecule of a 5 carbon sugar (ribose) to which is bonded a phosphate group (AMP). If this compound contains a second group, we have adenosine diphosphate (ADP) and if a third phosphate group is linked, we have ATP, adenosine triphosphate. All three types occur in living matter.

There are several ways in which ATP can be made - in plants by photosynthesis and by respiration; in animals by respiration only, usually in an oxygen-requiring mechanism. There is another process, fermentation, that also yields small amounts of ATP which does not require oxygen. Fermenting yeast cells and some bacteria can obtain their necessary ATP in this way. It should be no surprise then to learn that the ATP of Humans, animals and plants is the same and that the chemistry of its formation is essentially the same in all living matter.

During the energy-yielding degradation of foodstuff molecules, ATP is formed from ADP; some of the energy food is thus "saved" or conserved as the energy of the newly formed ATP. The chemical energy of ATP is then used to perform biological work.

When ATP is formed, the entire molecule becomes like a "loaded spring", loaded with energy that can be made instantly available. The many chemical steps in the charging and discharging of the ATP system is directed by the action of enzymes. This is the basic principle of the energy cycle in living matter and central to this cycle is the substance ATP.



A large number of ATP molecules is required every second by living matter. For example, it has been calculated that living matter requires about 1500 ATP's to synthesize a single protein molecule; about 2000 to form carbohydrate; to manufacture a giant nucleic acid molecule of DNA requires 120 million ATP molecules. For a single bacterial cell to reproduce itself prior to dividing, a minimum of 2,500,000 molecules of ATP are broken down to ADP and phosphate per second. As the entire bacterial cell contains only one million molecules of ATP, the rate of regeneration from ADP must indeed be extremely fast especially when one considers that a bacterial cell can divide once every 20 to 30 minutes. (It would be interesting for those of you who are mathematically inclined to calculate the number of ATP molecules a culture of bacteria would produce in 24 hours assuming you started with a single cell and division time was 30 minutes - and bacterial cells are only about 5% as efficient in producing ATP as are you and I!!!

Can you now understand why J. B. S. Haldane labeled them the "most lifelike molecules"?

Fermentation - "life without air" (Louis Pasteur) - Unit IV

"Our misfortunes inspired me with the idea of these researches", wrote Pasteur in the preface to a book describing his experiments on fermentation. "I undertook them immediately after the war of 1870, and have since continued them without interruption, with the determination of perfecting them, and thereby benefiting a branch of industry (brewing) wherein we are undoubtedly surpassed by Germany". Seeking in the brewery the "glorie" lost on the battlefield seems a strange motive to have led to epoch-making scientific work but overtones of national rivalries have motivated more than one research effort in the past. Stimulus for scientific discovery has often come from aims less exalted than the pursuit of knowledge and man's thirst for alcohol has done much to further man's understanding of his biological nature. (From The Biochemical Approach to Life; F. R. Jevons Basic Books, Inc., N. Y., 1964).

As we have said, food molecules, more specifically the chemical bonds in these molecules, are the ultimate energy source for living matter. Glucose is utilized by most cells as the food molecule, at the expense of the oxygen they take from the atmosphere to yield simple, stable end-products, carbon dioxide and water; this process yields a large amount of energy which is conserved in the form of ATP. This process is referred to as respiration. Cells that use oxygen are called aerobic cells or aerobes.

$$C_6H_{12}O_6 + 6\ O_2 \xrightarrow{\text{enzymes}} 6\ CO_2 + 6\ H_2O + ATP$$

However, there are a number of cells, especially some bacteria and other simple organisms which do not use oxygen at all, or are even poisoned by it. Such cells are called anaerobic organisms or, more simply, anaerobes.

In the entire realm of living organisms, only a few species are strictly anaerobic. These are usually microorganisms, particularly those which live in surrounding having little or no oxygen - in soils, in deep water, or in marine mud. Among these are some pathogens (i.e., disease-producers) such as the soil bacteria Clostridium welchii which causes gas gangrene in wound infections.

It appears that in the course of the evolution of life, anaerobes arose first since it is thought that the primeval atmosphere was wholly or largely devoid of oxygen. The antiquity of this method is further demonstrated by the fact that it follows the same lines in all organisms (both anaerobes and aerobes) for as some organisms become more specialized during evolution, they acquired the capacity to use oxygen while still retaining the fundamental fermentation mechanism.
Fermentation still remains the basic way of life for all types

of cells can survive for periods on fermentation if deprived of oxygen - even you and I. Only in aerobes, the process is labeled glycolysis instead of fermentation. Glycolysis literally means the "dissolution of sugar". The only significant difference lies near the end of the process. Instead of yielding alcohol and CO_2 as does fermentation, glycolysis forms another compound, pyrovic acid.

It might be of some interest to know that in the fermentation process, the alcoholic content can never exceed about 12% by volume (the alcoholic content of most wines), since alcoholic concentrations higher than this kill the yeast cells. They actually die in their own waste product - alcohol! Another of these wastes, carbon dioxide, provides the "bubbles" found in some alcoholic beverages. (In most wines, carbonation is actively discouraged.) The alcohol story is an interesting one from another viewpoint in that it wasn't until man learned to distill his alcohol (remove the alcohol from the fermenting mass by boiling) that he was able to produce hard liquor. Now he could simply add pure alcohol to his favorite flavored base (scotch, rye whiskey, etc.) in any concentration he desired (usually between 40 to 60% by volume). Pity the poor Romans who could drink at most only 12% alcohol - no wonder their parties lasted so long! But on with our story.

The evolution of complex organisms would have been altogether impossible had not anaerobic respiration been supplemented by aerobic mechanisms for in the primitive process of "life without air" only about 7% of the energy contained in glucose is ever conserved as ATP. Much of this energy is still locked up in the end-products of this process.

Let's now consider this "early way of doing things" to gain a bit of an understanding as to how fermentation underlies all other forms of metabolism.

Anaerobic breakdown of glucose always yields two molecular fragments with some of the energy released conserved as energy. To illustrate, beginning with a six carbon molecule - glucose $(C_6H_{12}O_6)$, two C_3 molecules are formed. It is important to remember that cells do not break down glucose just to dispose of it: they carry out this process largely to regenerate ATP from ADP and phosphate.

The real mainspring of energy in complex organisms is aerobic respiration in which fuel molecules are completely oxidized by molecular oxygen. The enzyme systems involved are far more complex than those concerned in fermentation or glycolysis. They involve many more enzymes and many more separate chemical steps. Furthermore, these enzymes do not occur in free form in the liquid portion of the cytoplasm. Rather, they are fixed in specific array in the mitochondria, which for reasons which will become obvious have been called the power plants of the cell.

It is desirable when burning fuel in mechanical or living engines, for the energy to be released in a controlled way. An energy liberation in small increments is to be preferred over an explosive release which might destroy or damage the machine or result in a waste of much of the energy (Figure 2a). The cell operates in a manner similar to that shown in Figure 2b, tapping off the energy in multiple stages and transforming it into ATP.

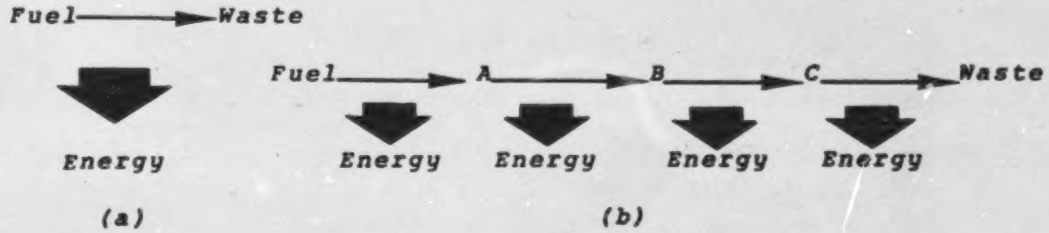


Fig. 2. a) Explosive and b) gradual energy release in fuel utilization. B is the method of choice in living systems.

To add still greater efficiency to the process, the stepwise mechanism functions as a cycle rather than a straight chain. This is represented by the wordless sequence in Figure 3. In this diagram, compound A forms B; B unites with C to form D which then undergoes a series of changes (D-E-F) to return once again to C. The cycle can then start over again using a fresh molecule of substance A. Such a cyclic process is to be desired since "self-regenerating" mechanism based on small molecular changes can better trap a higher proportion of the energy released.

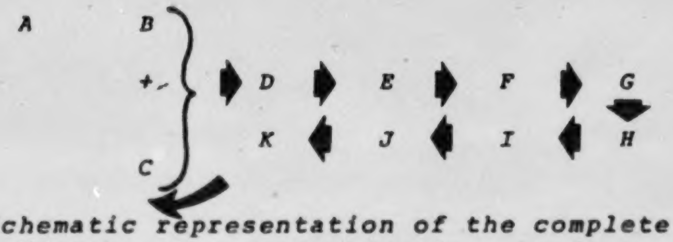


Fig. 3. Schematic representation of the complete oxidation of a food molecule. It is a cyclic process, returning to the starting point after each turn of the wheel.

This cycle, discovered by Hans Krebs in England, is popularly known as the Krebs Cycle and for his efforts he was awarded a Nobel prize in 1953. (He also was knighted by Queen Elizabeth).

Go to slide #25 and go back to cassette tape to continue the lesson.

BIOLOGY 100-A

UNIT V THE ORGANIZATION OF LIFE - PART II

OBJECTIVES FOR UNIT V - THE ORGANIZATION OF LIFE - PART II

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. EXPLAIN WHAT THE TERMS "COMPLEXITY" AND "ORGANIZATION" MEAN IN TERMS OF THE LIVING ORGANISM.
2. NAME THE THREE PHASES OF THE "ENERGY CYCLE" OF LIFE.
3. RELATE THE "PURPOSE" OF CHLOROPHYLL IN THE ENERGY CAPTURING REACTION OF PHOTOSYNTHESIS.
4. DESCRIBE GENERALLY THE "LIGHT" REACTION OF PHOTOSYNTHESIS.
5. COMPLETE THE FOLLOWING:

   IN PHOTOSYNTHESIS (TYPE) ENERGY IS CONVERTED TO (TYPE) ENERGY.
6. DESCRIBE GENERALLY THE "DARK" REACTION OF PHOTOSYNTHESIS. (WHAT TAKES PLACE, OVERALL?)
7. RESPIRATION IS OFTEN DESCRIBED AS THE REVERSE OF PHOTOSYNTHESIS. NAME AN ENERGY ASPECT WHICH IS AN IMPORTANT DIFFERENCE.
8. RELATE PARTS OF THE CELL TO SPECIFIC FUNCTIONS WHICH THESE PARTS CARRY OUT FOR THE CELL.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

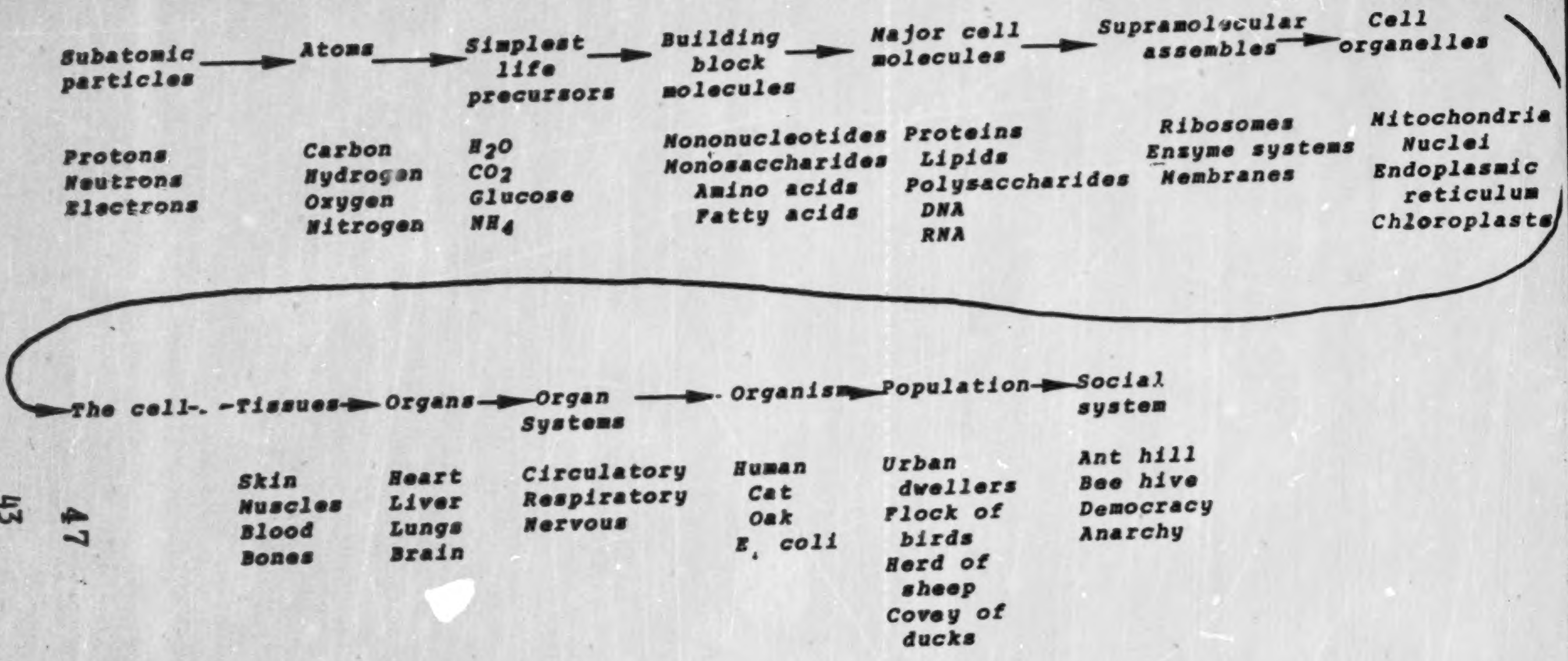
1. IN ORDER FOR EVOLUTION TO HAVE PROCEEDED BEYOND CERTAIN PRIMITIVE STAGES, PHOTOSYNTHESIS HAD TO APPEAR.

2. DISCUSS THE CHART ON PAGE 43 LABELLED "THE ORGANIZATION OF LIFE".

3. IN PUTTING THE IDEAS OF THERMODYNAMICS INTO EVERYDAY LANGUAGE IT WAS STATED:

   (1) "YOU CAN'T WIN"
   (2) "YOU CAN'T EVER BREAK EVEN"
   (3) "YOU CAN'T GET OUT OF THE GAME"

   WHAT IS THE RELATIONSHIP OF "ENERGY" TO EACH OF THESE STATEMENTS?



The organization of life.

Oxygen and the Ocean -

Many people believe that green plants produce a surplus of oxygen to replace that which is converted to carbon dioxide in burning of fuels or from metabolism. But this is not true. A plant produces only enough oxygen for its own use during its life (i.e., to carry on its own metabolism) plus enough extra for its removal thru oxidation, after its death to return back to the original molecules from which it was made - CO_2 and H_2O. Whether this oxidation occurs by fire, by bacterial decay or thru respiration of an animal or plant using it as a food source has no effect on the ultimate outcome. When the plant is totally consumed, that is returned to the basic molecules of CO_2 and H_2O, all of the oxygen it produced in its lifetime will also have been consumed. The only way a plant leaves an oxygen surplus is if it is not completely consumed. Study the equations:

Photosynthesis: $6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

O_2 on this side = O_2 on this side (count them)

Respiration. (or burning) $C_6H_{12}O_6 + 6O_2 \xrightarrow{6H_2O} 6CO_2 + 12H_2O$

O_2 on this side = O_2 on this side

Our present atmosphere contains about 20% oxygen. This surplus oxygen became available when back in geologic time, principally during the Carboniferous period, (400 million years ago) organic matter was deposited in the unoxidized state forming what we now call the fossil fuels → coal, petroleum and natural gas. Since that time, the combination of green plants and oxidizing organisms have apparently kept the O_2 in the atmosphere at its present level, returning it in amounts equal to the rate at which it is withdrawn. The point here is that our present oxygen atmosphere is due to the large reserves of fossil fuel. As we destroy more and more fossil fuels--as we are doing at an accelerating rate - the ratio of carbon dioxide to oxygen in the atmosphere will change. Why? As the O_2 content decreases, the atmosphere will come to resemble that found at increasingly higher altitudes (e.g., Mile-high Denver - 18% O_2).

If the plankton in the ocean were to all die tomorrow, land animals (including man) would not asphyxiate. The ocean animals would starve. The effect of this on the world's O_2 supply would be very small. Remember, for every molecule of food ($C_6H_{12}O_6$) there are six oxygen molecules out there somewhere. So, as long as we have food, there will be O_2 to consume it.

The effect on the world's food supply could be catastrophic in the event of massive marine destruction, especially for those nations that rely on seafood for protein (i.e., Japan).

Destruction of the world's forests would also have little effect on atmospheric oxygen. It is the stores of fossil fuels that are important and when these are gone (estimates range up to 400 years) then we are in trouble. Can the world afford to burn its fossil fuels?

Photosynthesis - "the other side of the coin" - Unit V

During the course of evolution, one important prerequisite for further development was the necessity to devise a way whereby the carbohydrates - the principal source of energy molecules - could be made. It is generally believed by scientists that for the first two or three billion years of this planet's existence there was no oxygen in the atmosphere, hence early development must have proceeded without the benefit of aerobic respiration, without O_2. Early organisms were apparently fermenters - which quite literally means "life without air". The carbon molecules used in fermentation were presumably formed by processes that did not depend entirely on other living systems. Reactions with oxygen appear late in terms of evolutionary events. However, the fundamental structure of metabolism is still anaerobic and within certain bounds quite adequate to sustain life. But, we have learned, that fermentation yields relatively few ATP molecules - hence, if complex organisms were to develop, some other way of extracting energy had to be found.

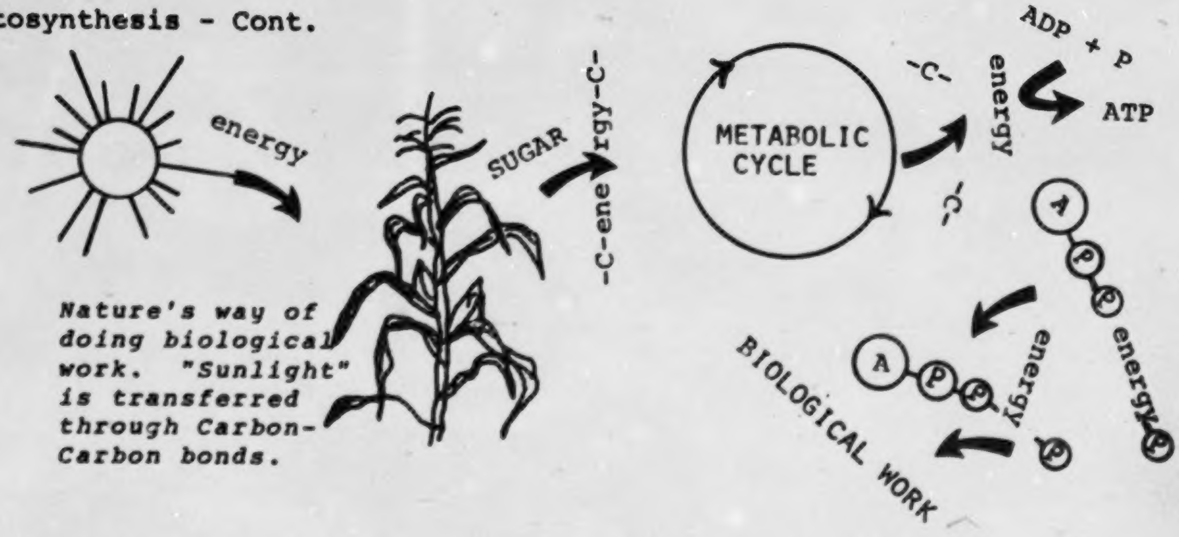
So then,the requirements for evolution to proceed were these: first, oxygen had to become available in large quantities to permit aerobic respiration and second, an abundant supply of carbohydrate to serve as food molecules. The mechanism which evolved to provide life's most basic demands was the well-known process, photosynthesis. Photosynthesis is even more complex than respiration because not only does it involve the principles of organization of the glycolytic system, the Krebs Cycle, and electron transport but also a rather elaborate molecular system for capturing light energy. Because of its complexity, it is not as well understood as respiration in its molecular detail, but it is currently an active and exciting field of biological research. (Incidentally, the University of Illinois has some of the outstanding scientists in photosynthesis research.)

We have already seen that the degradation of the glucose molecule to CO_2 and H_2O in respiration results in a large output of energy. Now, of course, it is well understood that energy does not simply arise from nowhere and so, photosynthesis, being the other side of the coin converts radiant solar energy absorbed by the chlorophyll of green plants into chemical energy. This in turn is used to "drive" the otherwise low energy molecules of CO_2 and H_2O to form high energy sugar as follows:

$$\underset{\text{(low energy)}}{CO_2 + H_2O} \xrightarrow[\text{energy}]{\text{solar}} \underset{\text{(high energy)}}{C_6H_{12}O_6}$$

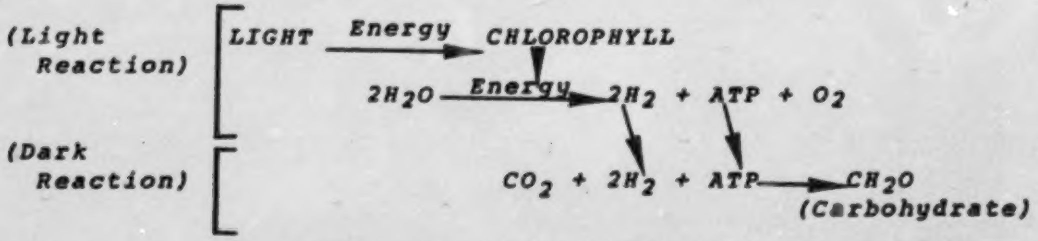
It is apparent that this equation is essentially the reverse of glucose oxidation. It is then fair to say that the energy extracted to do biological work is fundamentally "sun energy" which has undergone several conversions.

Photosynthesis - Cont.



Nature's way of doing biological work. "Sunlight" is transferred through Carbon-Carbon bonds.

The term photosynthesis applies to the total process by which glucose is formed from CO_2 and H_2O at the expense of solar energy. However, two distinct processes have been recognized as occurring in the overall synthesis of sugar. The first is the conversion of light energy to chemical energy since it is fairly obvious that living matter cannot use sunlight directly. Once the light energy has been captured and transformed into chemical energy, the second set of reactions by which glucose is formed from CO_2 can proceed in the absence of light. The first of these processes, the so-called light reaction is absolutely unique to photosynthesizing cells, whereas most of the dark reactions, by which the carbon skeleton of glucose is built from CO_2, occurs in non-photosynthetic organisms including you.



The two phases of photosynthesis.

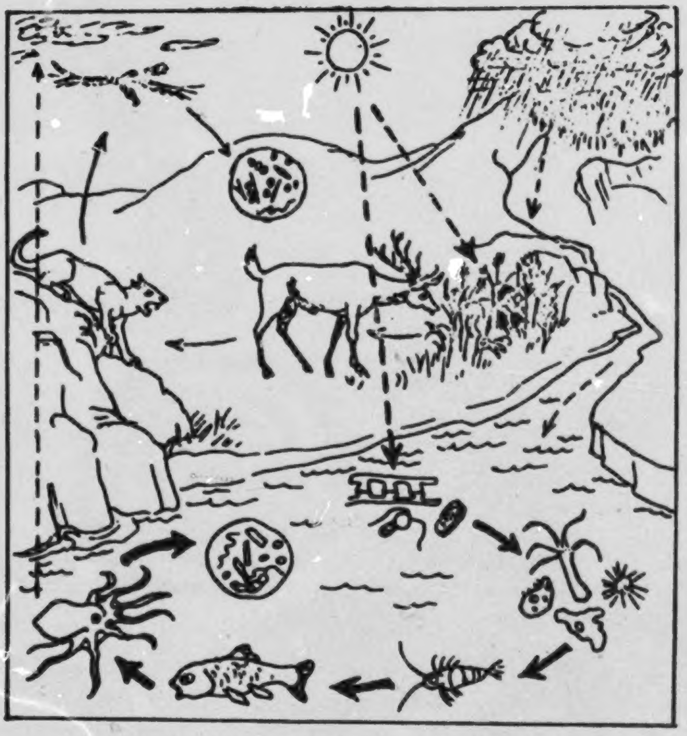
In the light reaction, water molecules are dissociated by energy supplied from the sun. It is an observation apparent to all that sunlight does not routinely "split" water. Here is where chlorophyll enters the action. It captures radiant energy and shuttles some of this energy into the demolition of water. After dissociation, some of the energy which held the molecules together is used to make ATP and some is utilized to charge up a carrier molecule by bonding some hydrogen from the splintered water to that molecule. This, of course, leaves some O_2 without a partner; this O_2 becomes free oxygen gas and goes out into the atmosphere to be used by aerobic organisms. This trapping of light energy and transforming it to chemical energy in the form of ATP and a hydrogen-charged carrier molecule occurs in chloroplasts; these contain the green coloring material of plants, chlorophyll. We may regard chlorophyll then as nature's apparatus for converting light energy to chemical energy. Again, the two most important products of the light reaction are the hydrogen-charged carrier molecules and ATP - both of these, highly energetic compounds. Of course, in postscript - the O_2 is important to you and me - we breathe it!

The second step, the dark reaction so-called because light is not necessary, makes use of these two highly energetic molecules, ATP and the hydrogen-charged carrier, and through a series of ten to twelve steps, converts CO_2 into the carbohydrate, glucose, in a process which is essentially the reverse of glycolysis. Although it is true that CO_2 fixation can occur in the dark, the plant can still only "make hay while the sun shines" since the prerequisites for the fixation are manufactured only with sunlight and these, being highly energetic, cannot be stored. They are directed into the fixation mechanism almost immediately upon formation. In fact, the entire photosynthetic process, both light and dark reactions, can be completed in a matter of just a 100 seconds.

To better grasp what is meant by such speed consider the following statistics: It is estimated that at present all the O_2 in the atmosphere passes through organisms - in by respiration and out by photosynthesis - every two thousand years; that all the CO_2 in both atmosphere and hydrosphere (all the waters on this globe) cycles through organisms in photosynthesis every 300 years; that all available CO_2 in the atmosphere would be tied up in plants in just two to three years if it weren't for respiration returning glucose to its baser ingredients; and all the waters of the earth are decomposed and recomposed by photosynthesis and respiration every two million years. Another example - each year photosynthesis uses 396 billion tons of CO_2 on this planet to make 270 billion tons of glucose. Although the figure varies, over 85% of the total world photosynthesis takes place in the oceans where it is carried out mainly by marine algae. Think of it - 85% of all photosynthesis occurs in the oceans. This is quite startling when one considers that you and I as terrestrial, land dwelling beings, sometimes think only in terms of our immediate surroundings. The trees, many and large, of the forests, the cornfields, the grasslands, the myriad plants growing on our immense continent alone - these it would seem provide the major photosynthetic factories - but in reality, the oceans far and away surpass the total land production on this planet, suggesting the potential which the oceans hold for the future if we could only learn to utilize them for the good of all and not in support of selfish or nationalistic interests.

Life does not exist everywhere in and on the earth. Rather, it is confined to an extremely thin shell that includes particularly the interfaces among land, air and water, no more than ten miles from top to bottom (remember the earth is 8,000 miles in diameter). What sets the limits to the biosphere? Reference to Figure 2 provides a major clue to the distribution problem. The energetic foundation of all life is converted solar energy - the major requirement for the penetration of life down into the cracks and crevices of the earth. The life-content of the ocean deeps, the surface of the desert, the jungles, depend fundamentally upon the transformation of radiant energy. Some living organisms can exist indefinitely in dark deep caves or in the eternal darkness of ocean depths, but with few exceptions they do so only by virtue of transfer to them of energy-rich compounds made by organisms living in the light. Clearly, however, life is not equally distributed everywhere, it occurs in patches of greater or lesser abundance, in conformity with local variations. The term "biomass" is applied to the total quantity of material that makes up the living organisms present in the given area. The biomass of the earth has never been measured. We have no idea how much the entire biota of the earth would weigh at this moment, nor how the figure changes from season to season, year to year or era to era.

We do know that the largest components are the autotrophic organisms, the green plants. A second component includes the heterotrophs, mainly animals, which feed upon the autotrophs. A basic cycle of energy is set up within the system - from sun and earth to autotrophs, from autotroph to heterotroph, from heterotroph back to earth, and so on. The steady supply of new energy from the sun powers the cycle and replenishes the inevitable leakage of energy out of the system in the form of non-recoverable heat as predicted by the 2nd Law. These energy systems, called ecosystems by biologists, may be very large and complex or relatively small and simple. However, it is worth mentioning that there are no completely isolated parts of the biomass - parts interact with other parts - O_2 and CO_2 are compartments of the biosphere flowing to and from the biomass. What is emphasized here is that all earthly life, for certain important reasons, can be conceived to be a single ecosystem. It may be a long time before we fully understand the complex interactions that occur within the ecosphere, and probably still longer before we comprehend its implications for the human community. We are just now awakening to the awesomeness of this realization. It is becoming more and more clear that if we change one component, every other component is affected - sometimes far removed from the original point of disturbance. It is really quite shocking to learn that there is no longer any fresh air on our continent. The west wind blowing fresh from the Pacific Ocean is already polluted with smog picked up from its previous circulation around the earth. Matter powered by energy flowing through the thin film of the biosphere is constantly altering its properties in response to environmental change. The ecosystem can be changed for better or for worse!



Energy cycle of the biosphere are powered by the sun. Land plants bind solar energy into organic compounds (heavy broken arrows). Residual compounds are decomposed by bacteria (light solid arrows) Energy is fixed by microscopic sea plants in photosynthesis (heavy solid arrows). In the water cycle (light broken arrows) water evaporated from the sea is precipitated on land and used by living organisms, and eventually returns to the sea carrying minerals and organic matter. (From Cole, Scientific American, April 1958).

BIOLOGY 100-A

UNIT VI THE CONCEPT OF APPROPRIATE SIZE

OBJECTIVES FOR UNIT VI - THE CONCEPT OF APPROPRIATE SIZE

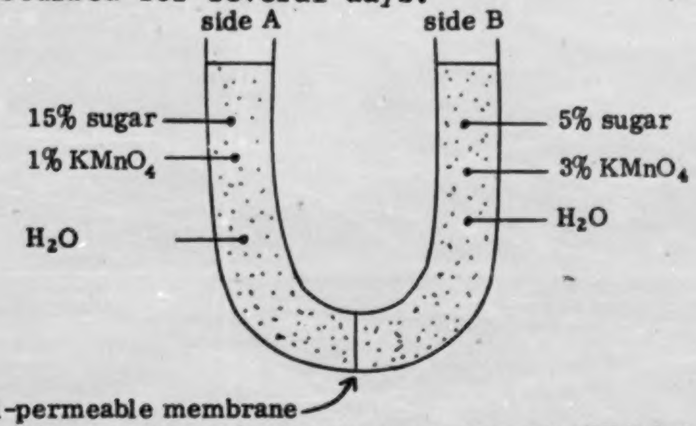
THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. DISCUSS WHY INCREASE IN THE SIZE OF AN INDIVIDUAL CELL BEYOND A CERTAIN LIMIT DOES NOT OCCUR AS THE ORGANISM GROWS LARGER.
2. COMPARE DIFFUSION AND OSMOSIS; HOW ARE THEY SIMILAR; HOW DO THEY DIFFER?
3. GIVEN A DIAGRAM ILLUSTRATING OSMOSIS, THE STUDENT WILL BE ABLE TO SHOW DIRECTIONAL MOVEMENT OF WATER BASED ON CONCENTRATIVE DIFFERENCES.
4. DEFINE THE "SCALE EFFECT". DISCUSS HOW IT RELATES TO OSMOSIS AND DIFFUSION.
5. DEFINE THE RELATIONSHIP BETWEEN THE SIZE OF A CELL AND ITS RATE OF METABOLISM.
6. DESCRIBE WHAT HAPPENS TO A FORM LIKE A VIRUS WHEN IT BECOMES TOO SMALL TO EXIST IN A CELLULAR STATE.
7. NAME TWO SOLUTIONS THAT CELLS AND/OR ORGANISMS HAVE DEVISED TO EXPOSE ADDED SURFACE AREA TO AN ENVIRONMENT.
8. NAME SEVERAL WAYS PLANTS HAVE RESOLVED THE SURFACE AREA TO VOLUME RELATIONSHIP IN THEIR EXISTENCE.
9. NAME SOME FACTORS WHICH LIMIT HOW LARGE AN ORGANISM CAN GET.
10. SHOW THE RELATIONSHIP WHICH EXISTS BETWEEN SIZE, RATE OF METABOLISM, AND MAINTENANCE OF CONSTANT TEMPERATURE.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. POPULAR MOVIES OFTEN SHOW ENLARGED FORMS OF THIS OR THAT ANIMAL MARAUDING CITIES, EATING PEOPLE, AND TAKING OVER THE WORLD. DISCUSS WHAT YOU HAVE LEARNED IN THIS UNIT TO DISCOUNT THESE POSSIBILITIES.
2. DISCUSS THE QUESTION: WHY DOES A CELL DIVIDE? (YOU HAVE COVERED INFORMATION IN THIS UNIT WHICH SHOULD ANSWER THE QUESTION.)
3. DISCUSS WHAT IMPACT THE CONCEPT OF "SIZE" HAS HAD ON THE EVOLUTION OF LIVING THINGS.

For Review (1): The following details were involved in the experiment pictured: at the beginning of the experiment the liquid volumes were equal in both tubes, a semipermeable membrane separated the two solutions; the apparatus was allowed to stand undisturbed for several days.



Given: permeable to water and potassium permanganate ($KMnO_4$)
impermeable to sugar

1. During the experiment, what would happen to the water level?

   (a) It will rise in A since water will diffuse from a region of greater concentration to a lesser one.

   (b) It will rise in B since water will diffuse from a region of lesser concentration to a greater one.

   (c) It will remain the same.

2. What will happen to sugar in A?

   (a) It will become more concentrated and B will become less concentrated since water moves from A to B.

   (b) It will become more concentrated and that on B less concentrated since water passes from B to A.

   (c) It will become less concentrated and B will become more concentrated since water passes from A to B.

   (d) It will become less concentrated and that on B will become more concentrated since water passes from B to A.

3. Which of the following best describes what will happen to $KMnO_4$ during the experiment?

   (a) There will be no passage of $KMnO_4$ because solutes do not go thru semi-permeable membranes.

(b) There will be a slight passage of this substance, but the passage will be restricted by the size of the pores of the membrane.

(c) There will be a slow movement since the concentrations are about equal.

(d) There will be no passage since $KMnO_4$ is insoluble.

4. If we could insert a pressure-measuring device, on which side would the pressure be greatest:

(a) Side A at the beginning of the experiment.

(b) Side A at the conclusion of the experiment.

(c) Side B at the beginning of the experiment.

(d) Side B at the end of the experiment.

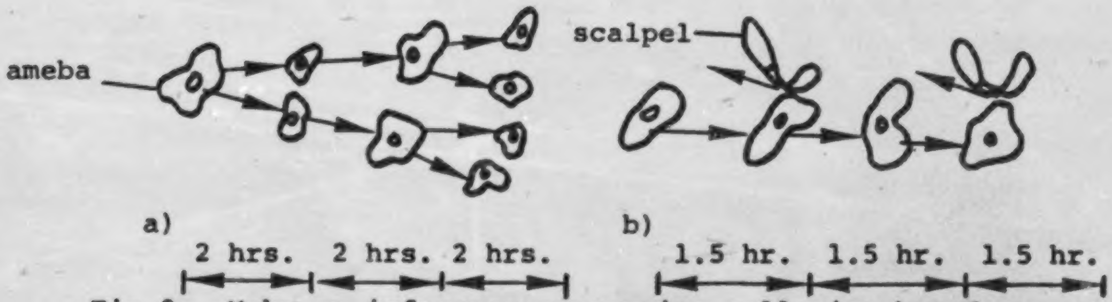


Fig 2. Make an inference concerning cell size based on the results of the diagrammed experiment.

Inference: ____

____

____

GO TO SLIDE 15 START TAPE

BIOLOGY 100-A

UNIT VII WHAT DO WE INHERIT?

OBJECTIVES FOR UNIT VII - WHAT DO WE INHERIT?

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. TO DISTINGUISH BETWEEN CHARACTERISTICS WHICH ARE ACQUIRED THROUGH BIOLOGICAL TRANSMISSION AND THOSE WHICH ARE CULTURALLY TRANSMITTED.
2. TO EXPLAIN IN GENERAL TERMS THE PROCESS OF FERTILIZATION AND HOW THIS IS RELATED TO GENETIC TRANSMISSION.
3. TO DEMONSTRATE HIS (HER) KNOWLEDGE OF HUMAN CHROMOSOMES BY RELATING THE NUMBER PER NORMAL CELL TO THAT OF A GAMETE AND BY EXPLAINING THE RELATIONSHIP BETWEEN GENES AND CHROMOSOMES.
4. TO USE THE TERMS HOMOZYGOUS AND HETEROZYGOUS IN EXPLAINING VARIABILITY.
5. TO DEMONSTRATE HIS (HER) KNOWLEDGE OF MEIOSIS BY DIAGRAMMING THE STEPS INVOLVED TO INCLUDE WHEN AND HOW CROSSING-OVER OCCURS.
6. TO RELATE THE VARIATION RESULTING FROM THE PRODUCTION OF MANY KINDS OF SEX CELLS TO THAT FOUND IN THE GREAT NUMBER OF DIFFERENT ZYGOTES.
7. TO USE THE TERMS AUTOSOMES AND SEX CHROMOSOMES AND EXPLAIN HOW THE DIFFERENT SEXES ARE PRODUCED.
8. TO INTERPRET A SIMPLE PEDIGREE CHART.
9. TO USE THE TERMS PLEIOTROPY, AND EXPRESSIVITY PENETRANCE TO DISCUSS A GENETIC CONDITION.
10. TO GIVE SEVERAL EXAMPLES FROM PERSONAL KNOWLEDGE OF HOW ENVIRONMENT CAN MODIFY HEREDITARY ENDOWMENTS.
11. TO COMPARE THE TERMS PLOIDY AND NON-DISJUNCTION.
12. TO EXPLAIN IN GENERAL TERMS HOW TURNER'S AND DOWN'S AND KLINEFELTER'S SYNDROMES ARE CAUSED.
13. TO COMPARE THE CONDITION KNOWN AS PKU WITH DIABETES.
14. TO EXPLAIN WHAT IS MEANT BY THE PHRASE "GENES ARE CHEMICAL PACKAGES OF POTENTIALITIES"

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. DO YOU THINK THAT A PERSON SHOULD BE HELD LEGALLY RESPONSIBLE FOR HIS ACTIONS EVEN THOUGH HE MAY HAVE A HEREDITARY PREDISPOSITION TOWARD THOSE ACTS?
2. WHY DO YOU THINK IT IS THAT IN PRACTICALLY EVERY SOCIETY THERE HAS DEVELOPED A TABOO AGAINST CLOSE INTERMARRIAGE?
3. OF WHAT SIGNIFICANCE IS CROSSING-OVER TO EVOLUTION?
4. SHOULD WE HAVE A "MAXIMIZING" OR A "NORMALIZING" ENVIRONMENT?

Glossary of Genetics Terms - Unit VII

1. Allele - One of two or more alternative hereditary units or genes. Ex. The gene responsible for color blindness is an allele of the alternative normal gene.
2. Autosome - Any chromosome other than a sex chromosome.
3. Backcross - The mating of a hybrid to one of the parental varieties or species.
4. Centromere - A definite region of the chromosome which binds together the two chromatids and to which is attached the spindle fibers during mitosis or meiosis.
5. Chromatid - Either one of the two identical strands or daughter chromosomes formed during mitosis or meiosis.
6. Chromosome - Deeply staining bodies visible under the microscope in the cells, especially at the time of cell division. The chromosomes consist essentially of genes, arranged in linear order.
7. Crossing-over - The exchange of corresponding blocks of genes between chromatids of homologous chromosomes resulting from breakage and fusion during meiosis.
8. Dihybrid - An individual which is hybrid (heterozygous) with respect to two pairs of genes.
9. Diploid - Referring to the double set of chromosomes found in body cells.
10. Eugenics - The science concerned with the development and application of methods for the genetic improvement of the human species.
11. F_1 - Offspring resulting from the crossing of two homozygotes.
12. F_2 - Offspring resulting from the crossing of two F_1's.
13. Genotype - The genetic make-up of an individual.
14. Haploid - The reduced or single set of chromosomes found in a gamete (sex cell).
15. Heterozygote - An organism with a gene pair of unlike genes which will produce two kinds of gametes with respect to this gene pair.

16. Homologous chromosomes - Chromosomes occurring in pairs; one from the sperm, the other from the egg.

17. Homozygote - An organism with a gene pair of like genes which will produce only one kind of gamete with respect to this gene pair.

18. Hybrid - An offspring resulting from a cross between parents which differ in one or more genes.

19. Meiosis - Two successive cell divisions which give rise to haploid cells.

20. Multiple alleles - A series of three or more alternative alleles which occur in an individual two at a time.

21. Phenotype - The physical appearance of an organism.

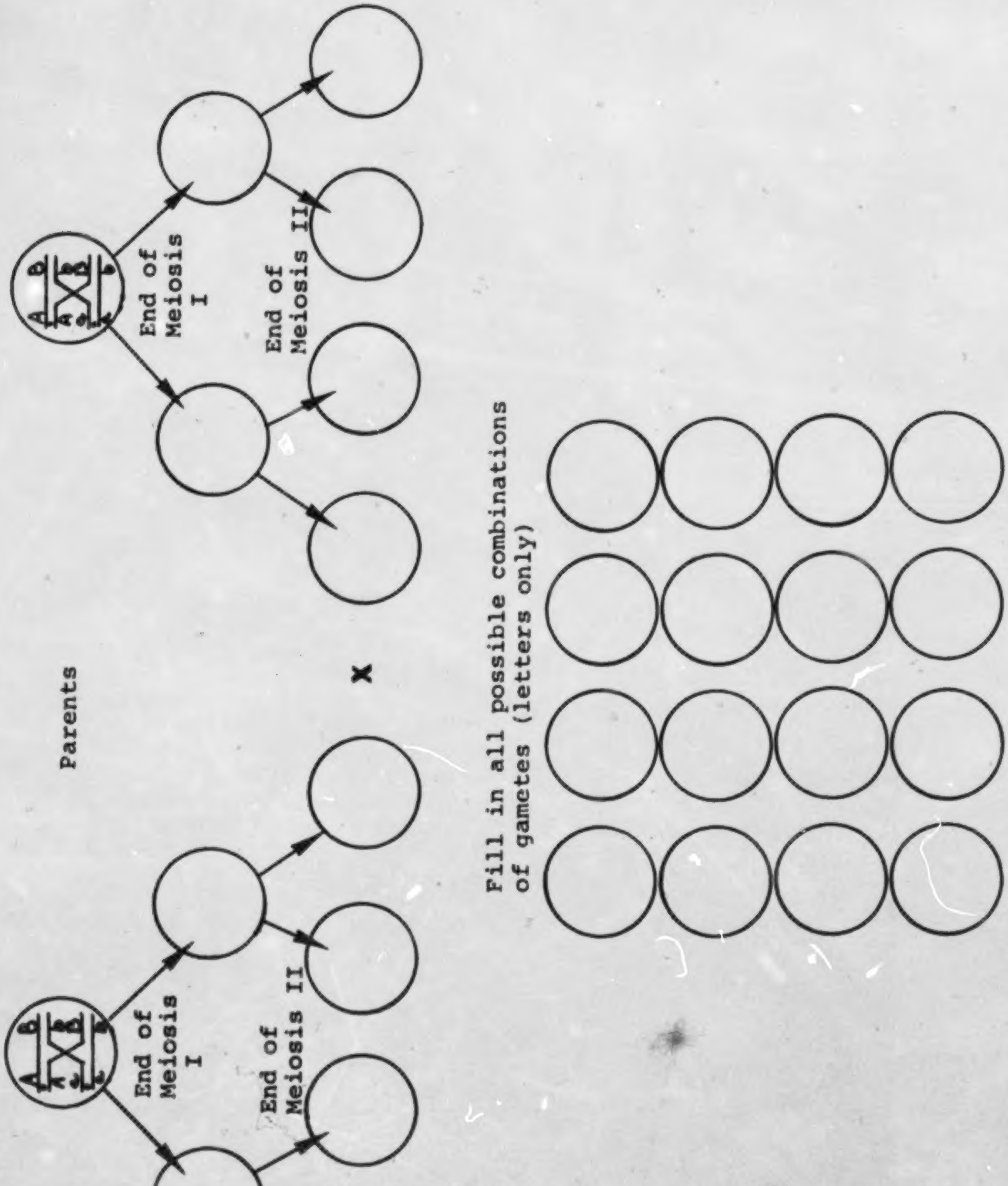
22. Pleiotropic gene - One which produces two or more distinct effects in an individual.

23. Polyploid - An unusual organism with three or more sets of chromosomes.

24. Sex chromosomes - Chromosomes concerned especially with the determination of sex. In most animals, two X chromosomes form a female and an XY combination gives rise to males. In birds, some moths and some fishes, the male is XX and the female is XY. In some invertebrates the female has two X chromosomes and the male has only one X and no Y.

25. Sex linkage - Refers to genes found on the sex chromosomes.

Activity Crossing-Over UNIT VII



Fill in all possible combinations of gametes (letters only)

Activity PTC and You UNIT VII

How unique is one's taste? Some people say taste is all in one's head and so it is, but not necessarily in the mind. Let's consider PTC tasters and non-tasters. PTC is an abbreviation for phenyl-thio-carbamide, a chemical that is tasteless to non-tasters (logical) and tastes bitter to most tasters (a few tasters assign its taste various other descriptions). The ability to taste PTC is inherited. An important (or at least interesting) observation is that tasters cannot taste the substance unless it becomes dissolved in the individual's own saliva. Dissolving PTC in water or dissolving it in someone else's saliva will produce no taste in a taster when placed on a dried area of the tongue. If it is dissolved in the individual's own saliva however, the PTC can be tasted. Non-tasters cannot taste PTC under any of these conditions. The indication is that each individual's saliva is different and the difference affects the individual's taste. Other evidence points in the same direction. The amounts of various substances secreted as part of the saliva varies extensively from individual to individual. An example is the amount of various amino acids (remember them?) found in the saliva. The table below shows the range in values for the amount of uric acid plus some of the amino acids in the saliva of nine individuals from which repeated samples of saliva were taken. Two things should be noted about these values - first, the relatively wide range of amounts for each substance (column 2) and second, each amino acid was detected in less than all of the samples (column 3) - 89% of the samples contained varying amounts of glutamic acid whereas only 33% contained varying amounts of aspartic acid; thus 54% of the samples contained some glutamic acid but not aspartic acid. Other similar variations can be derived from the table as well. Indications are that a seemingly nondescript substance - saliva- may be quite individualistic.

Test yourself to determine your ability to taste PTC.

Taster_________ Non-taster_______(Check your response)

Salivary Amino Acid Secretion Patterns

Substance	Range for Different Individuals, Mg/ml.	Per Cent Secreting Detectable Amounts
Uric acid	2.5-150	100
Aspartic acid	0 - 3.3	33
Glutamic acid	0 - 20	89
Serine	0 - 12	44
Glycine	0 - 36	89
Alanine	0 - 29	89
Lysine	0 - 15	44

BIOLOGY 100-A

UNIT VIII How Like Begets Like - The Genes at Work

OBJECTIVES FOR UNIT VIII - HOW LIKE BEGETS LIKE - THE GENES AT WORK

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. TO DISCUSS THE THREE PROPERTIES REQUIRED OF GENETIC MATERIAL.
2. TO EXPLAIN THE SIGNIFICANCE OF GRIFFITH'S EXPERIMENTS ON PNEUMOCOCCUS.
3. TO RELATE THE STRUCTURE OF A VIRUS TO ITS ABILITY TO ATTACK A LIVING CELL.
4. TO DIAGRAM A NUCLEOTIDE UNIT AND EXPLAIN HOW THESE UNITS FORM A DNA MOLECULE.
5. TO GIVE AN EXPLANATION FOR THE FACT THAT PROTEINS ARE CALLED THE "MACHINERY OF THE CELL".
6. TO DISCUSS THE RELATIONSHIP BETWEEN THE GENETIC CODE AND PROTEIN SYNTHESIS.
7. TO DEFINE CELL DIVISION IN TERMS OF DNA DUPLICATION.
8. TO COMPARE THE PHASES OF MITOSIS WITH REGARDS TO THE SHAPE OR POSITION OF THE CHROMOSOMES OF EACH.
9. TO EXPLAIN THE ROLE OF THE RIBOSOME IN PROTEIN SYNTHESIS.
10. TO RELATE THE ROLL OF MESSENGER RNA TO TRANSFER RNA.
11. TO COMMENT ON THE RELATIONSHIP BETWEEN A SPECIALIZED CELL AND THE GENES WHICH IT POSSESSES.
12. TO EXPLAIN WHAT IS MEANT BY THE TERM "GENETIC BLOCK".
13. TO DISCUSS THE VARIOUS ASPECTS OF THE SICKLE-CELL ANEMIA SYNDROME.
14. TO RELATE THE BIOCHEMICAL PATHWAY OF PHENYLKETONURIA TO THE FACT THAT THIS IS A GENETIC DISEASE.
15. EXPLAIN MUTATIONS IN TERMS OF THE GENETIC CODE.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. WHAT WOULD BE A PRACTICAL AND WORKABLE SOLUTION TO GENETIC DISEASES SUCH AS PHENYLKETONURIA?

2. DO YOU THINK THAT IF A GENETICS COUNSELOR TOLD A COUPLE THAT THEY HAD A ONE IN FOUR CHANCE OF HAVING AN ABNORMAL BABY THAT THIS SHOULD DETER THEM FROM HAVING CHILDREN?

3. IF SCIENTISTS HAD THE ABILITY TO CHANGE DNA, SHOULD THEY DO SO?

UNIT VIII - Mitosis in Plant Cells

The onion root tip is one of the most widely used materials for the study of mitosis, since it is available in quantity and preparations of the dividing cells are easily made. The chromosomes are relatively large and few in number, and hence they are easier to study than the cells of many other organisms. There are regions of rapid cell division in root tips; the chances are therefore good that within such tissues one can identify every stage in mitosis. There are several reasonably distinct stages in cell division, although the process is continuous and there is some gradation between the various steps. These steps in sequence, are prophase, metaphase, anaphase, and telophase (see Fig. 1).

Obtain a slide of onion root tips. Hold the slide above a sheet of white paper, and note on it a series of dark streaks. Each streak is a very thin longitudinal section through an onion root tip.

Place the slide on the stage of the microscope and locate one of the sections under low power. It is often possible, under power, to determine whether a given section shows good mitotic stages. Since each section is very thin, not all will be equally good for study. After preliminary examination under low power, change to high power, being very careful not to break the slide. Keep in mind the sequence in which the different stages occur, but do not try to find them in sequence. Thus, if you happen to find an anaphase first, study it before proceeding to another stage. Most of the cells will probably be in interphase or "resting" phase. Why is this not a good term to use?

The next largest number will be in prophase, and only a few will be seen in metaphase, anaphase, and telophase. The reason is that these cells remain in interphase and prophase longer than in the other stages.

(a). During prophase the chromosomes become distinguishable in the nucleus. The nuclear membrane breaks down, and the chromosomes become distributed randomly through the cytoplasm. At this stage in the onion root tip, the chromosomes often appear as a coiled mass, and in some cases the nuclear membrane may still be intact. These elongated chromosomes later become condensed into shorter chromosomes and the nuclear membrane disappears. Even at this early stage each chromosome has probably doubled, although this will be difficult to see on the slides.

(b). During metaphase, the chromosomes arrange themselves near the center of the cell. In the onion, the ends of the chromosomes will protrude into the cytoplasm on each side of the center of the cell. The metaphase stage is apparently a preparation for the equal division of chromosomes between the daughter cells, a process which begins in the next phase. During or somewhat before metaphase, small threadlike structures called spindle fibers form in the dividing cell. The function of these fibers is still debatable and they are often hard to see. Some of them appear to be attached to the chromosomes, and they may assist the chromosomes in their movement to the opposite sides of the cell. The fibers usually appear most clearly in the next stage.

(c). At the beginning of anaphase the members of each of the previously doubled chromosomes separate, one moving toward one side of the cell the other toward the opposite side. This stage can be recognized in the onion because there will be two groups of V-shaped chromosomes on opposite sides of the cell. The sharp end of the V is pointed toward the cell wall, the open end toward the center of the cell. The onion has sixteen chromosomes; hence it is seldom possible to see all of them at one time. Cut down the light on the microscope, and see if you can find any spindle fibers near the center of the cell. They will appear as very fine lines between the two groups of chromosomes, but they are often not visible in a study of this kind.

(d). Cell division is completed during telophase, and reorganization of the cell contents of the two daughter cells begins. It is often difficult to distinguish between late anaphase and early telophase in the cells of the onion root tip. During telophase, however, a cell plate starts to form across the center of the cell, which when complete will divide the original cell into two daughter cells. This cell plate will appear as a fine line that passes across the dividing cell, and in some cells it will not be noticeable. Another point of difference between telophase and anaphase is that during telophase individual chromosomes are not as distinct as in anaphase. As telophase progresses, the nuclei begin to reorganize and the chromosomes become indistinct in the chromatin throughout the nuclear material.

In both plant and animal cells, the daughter cells resulting from mitotic division have the same number and kinds of chromosomes as the original cell from which they come. Thus, in the onion, each daughter cell has sixteen chromosomes, just as the original cell had. This is not so evident in the slides you have already studied, because specially prepared slides and considerable experience in their study are necessary before this many chromosomes can be accurately counted.

One difference in mitosis between most plant and animal cells should be pointed out at this time. When plant cells divide a cell plate forms, as we saw in the onion root tip. This is probably correlated with the fact that plant cells have a nonliving cell wall. As previously noted, animal cells do not have a cell wall but are surrounded only by the plasma membrane. When most animal cells divide, there is a constriction near the center of the original cell. This constriction, which goes completely around the cell, deepens until the cell is pinched into two daughter cells.

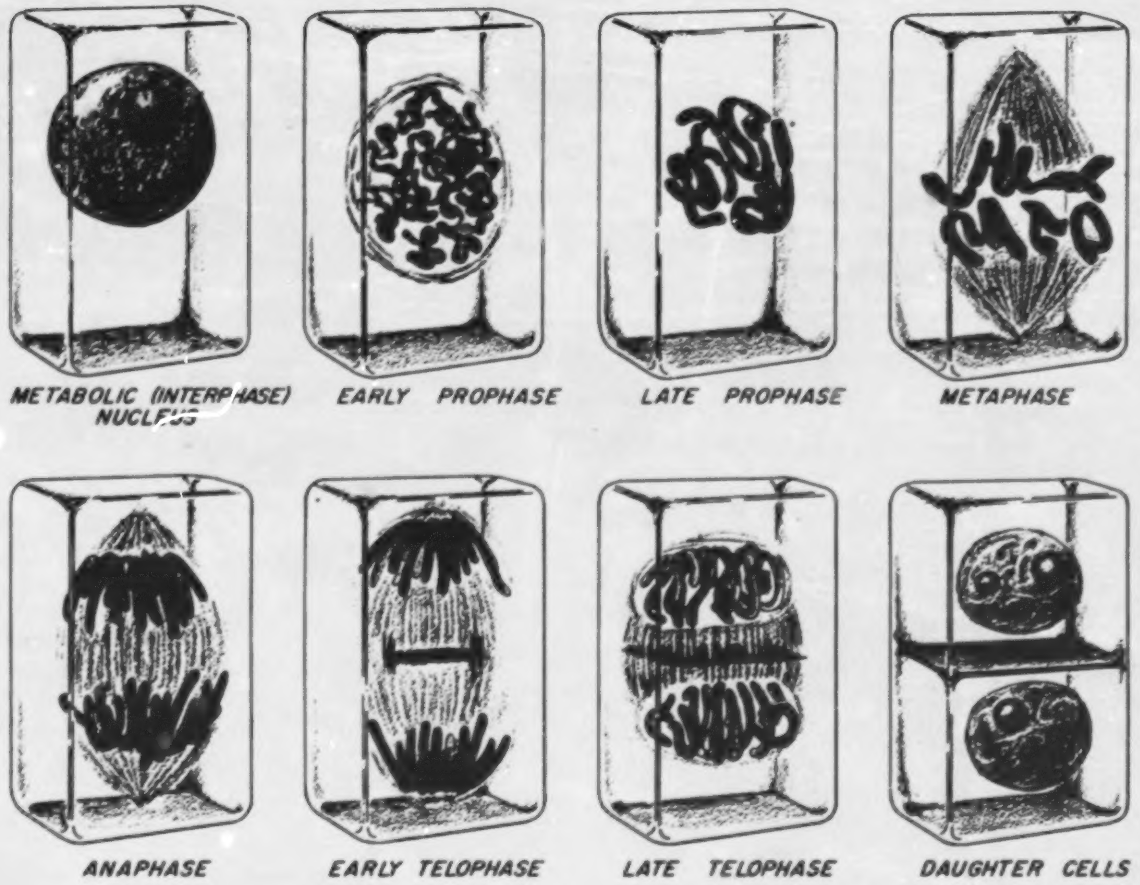


Fig. 1 Mitosis in Plant Cells

UNIT VIII

"Hormones and Genes" - Scientific American Offprint # 1013
Erich H. Davidson

1. All of the nucleated cells of an organism contain a similar copy of the DNA. What problems does this pose as we attempt to more clearly understand cell function or cell specialization?

2. A plant, after being kept in the dark is exposed to light. It immediately begins to manufacture messenger RNA for the synthesis of chlorophyll. What does this indicate about gene action?

3. Different hormones are thought to work in different ways. Gene regulation is suggested as one important method. Construct a model (verbal or by use of diagram) that might explain such an effect as the appearance of secondary sex characteristics. (e.g., body shape, accessory sex glands, etc.)

4. Why are the sex hormones (estrogen and testosterone) ideal for studying the relationships between hormones and genes?

5. Ecdysone, an insect hormone important in the molting process, is thought to have an effect on gene activity by causing swelling or puffs at specified locations on chromosomes in insects. How does this observation allow for such an interpretation?

6. Can you see any "practical" application of the research described in this article?

SICKLE CELL ANEMIA - UNIT VIII

In sickle-cell anemia (or Sicklemia) most of the red cells of a sample of fresh blood look normally discshaped until deprived of oxygen, when the characteristic sickle or crescent-shaped forms with threadlike extremities appear. Reexposure to oxygen causes immediate reversion to the disc form. Only patients with the homozygous (inherited from both parents) form of the disease are anemic. Their red cells begin to sickle when exposed to oxygen concentrations like those of the normal venous blood. Much lower oxygen concentrations are required to cause sickling of the cells of the nonanemic, heterozygous (inherited from only one parent) form.

In 1949 the sickling phenomenon was shown by Linus Pauling of the California Institution of Technology to be associated with an abnormal electric charge on the molecule, accounting for most of the hemoglogin in the severely anemic form but for somewhat less than half that in the heterozygous patients.

The gentic abnormality that causes sickling (it occurs mainly in black people, and far less frequently in Italians, Greeks and other peoples living around the Mediterranean Sea) may at one time have been benefical. Sickled cells resist malaria, and people who had them may have had a better chance for survival during malaria epidemics that have ravaged African populations. But today, its possible usefulness gone, sickle cell anemia remains a torture and killer of blacks, a dread disease against which America's Black communities are mounting a counteroffensive.

About one in every 10 American blacks carries the traits. Most of these carriers have very little sickling in their blood and have no trouble from it at all during their lives. But if two trait carriers marry and have children, they can expect one out of four of their children to have the severe disease which we call sickle cell anemia.

In detection of sickle cell anemia, a blood sample is combined in a solution of potassium phosphate, sodium dithienite, and sapenin. Clouding of the solution may indicate it but is not specific for the trait or the disease. If urea is then added and the solution becomes clear, then it is present. This test does not distinguish between those who have the trait and those who have the disease but singles out those who should seek further attention.

Dr. R. M. Nalbandian in 1970 claimed to have relieved the condition of one patient by injecting large amounts of urea, which breaks the hydrophobic bonds between the valines. Dr. A. Cerami, working on the theory that one of the impurities of urea was responsible, singled it down to cyanate which he found worked better because the effect was permanent and only samll amounts were required. Experimentation on animals have turned up no ill effects. Testing in humans is measuring the effects on the red blood cell's life span and so far cyanate is increasing the life of the red blood cells and reducing the sickling effect.

In May 1972 Nixon signed a bill providing $25 million for 1973, 40 for 1974, 50 for 1975, 10 million to be spent by the end of 1972.

Ten comprehensive centers were set up, 34 research contracts were let, and 19 screening and education clinics were established. The new program has four parts: educating the public, screening, gentic counseling, and referral of patients for treatment.

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"Fixing Sickle Cells," Newsweek, LXXIX (April 24, 1971), 103.

The Genetic Control of Development UNIT VIII

At the Demonstration Table are petri dishes prepared for your examination. They contain the red-colored bacterium, Serratia marcesans, which owe their color to the pigment prodigiosin. The pigment is the product of a chemical sequence similar to the one in slide #28. Individual concentrations of these organisms are termed colonies, with each colony containing about 50 million bacterial cells. It is further interesting to observe that each colony resulted from a single bacterium placed on the agar surface. If 20 colonies are present, there were 20 original cells on the plate. Reproduction is by the asexual process, cell division (mitosis).

Prior to incubation, these plates were exposed to ultraviolet light (UV). This high energy light (radiation) can produce a change in the DNA code resulting in a mutation which can then be passed on to succeeding generations.

Not all the colonies in the dish have the same degree of color. This is because production of pigment is due to the activity of several genes (multiple genes). The number of genes involved has not been fully determined.

1. Notice the variety in color types, red, orange, white, etc.
2. Explain in your own terms what probably happened to produce these changes.

Case Histories - UNIT VIII

(From Counseling in Medical Genetics - Reed)

I. Rh Disease

Up until the last decade, it was not uncommon for some couples to have a normal first baby and have their second child die from hemolytic disease of the newborn (Rh Disease). If you were to study such a couple; what would you learn their genetic makeup to be with respect to the Rh factor; why was the first baby born healthy, and what might now be done for such a couple to prevent this tragedy?

II. Albinism

The frequency of albino births is 1 in every 20,000 approximately. Now the surprise! With a proportion of 1 in 20,000 of the population being homozygous, what proportion of the population do you think is heterozygous for the albino gene? The answer is 1 out of 70 persons carries the gene for albinism. This is determined by applying the Hardy-Weinberg Law which states that an equilibrium exists between heterozygotes and homozygotes. The equilibrium is in the form of the binomial expansion $(p + q)^2 = p^2 + 2\ pq + q^2$ where q is the frequency of the albino allele. The homozygous albinos are represented by q^2 or 1/20,000. The square root of 1/20,000 equals 1/141 equals q. If $p + q = 1$ then $p = 1-q$ so $p = 1 - 1/141$ or 140/141. The frequency of heterozygotes is expressed by 2 pq so 2 (140/141) (1/141) = 280/20,000 or 1/70 approximately.

ILLUSTRATIVE EXAMPLE

Request A physician delivered an albino child to a prominent young couple. They were much perturbed about the situation, but the physician told them that if the child were kept from the prying eyes of relatives and neighbors for a few months it would darken up and everything would be fine. The couple received assurances that it was just an accident and could not happen to them again. After about a year the couple decided that some mistake had been made, as the child was still definitely an albino. They came to the Dight Institute.

Reply As the young parents were intelligent and well educated in most respects, a short conversation was all that was necessary to explain both the chemistry and the genetics of albinism. Their confusion departed and they made their decision for the future on the spot, without further assistance. Their 1 in 4 chance of an albino at each subsequent pregnancy was an unpleasant surprise but one which they were able to comprehend and accept with fortitude.

III. Down's Syndrome (Mongolism)

Down's syndorme is caused by the presence of one extra chromosome, namely number 21. This is caused by a failure of the homologous chromosomes to separate during meiosis resulting in a gamete, most often an egg, having two of chromosome number 21 and the resulting zygote would then have three. This non-disjunction is definitely affected by the age of the mother. If the age of the mother is between 20 and 25, her probability of having a mongoloid is around .03%, but if she is between 45 and 50 the probability has risen to 2.6% or an increase of almost a hundred times. The overall frequency for the population is around 1 per 600 births. This type of temporary nondisjunction is usually random so that if a young mother has a first child with Down's syndrome, the probability that she will have a second child with it is about the same as the general population or 1 in 600. However this chromosome upset can be caused by a translocation, this means that she has one #21 and one #15 which are separate and one translocated chromosome made up of a #21 and #15 joined together. She can produce six different kinds of gametes. Of these, three will be lethal, one will cause Down's syndrome, one will form a normal offspring, one will form a carrier. So the probability of a carrier mother giving birth to a mongoloid is 1 in 3 not 1 in 600, a great difference. If a young mother has a mongoloid baby, then an examination of her chromosomes (a karyotype) should be made before advising her as to whether or not she should have a second child

IV. Cystic Fibrosis (Fibrocystic Disease)

Cystic fibrosis is the most common gentic disease among Caucasians. In the United States, it occurs once in every 2,000 births, It is caused by an autosomal recessive gene which when homozygous causes malfunctions of the liver, pancreas and intestine. It was once a fatal disease but now early diagnosis and intensive treatment make it possible for victims to live fairly normal and active lives. However, it is still a very dangerous disease for children. Carriers cannot be detected yet.

If you were a gentics counselor, how would you explain the gentic aspects of cystic fibrosis to a young couple in each of the following situations?

1. A couple with no record of cystic fibrosis in either family.
2. A couple inquiring about a second child with the first child having cystic fibrosis.
3. A couple expecting their first child where the future mother has a sister with cystic fibrosis add the future father's mother also had it.
4. A couple expecting their first child where the father has cystic fibrosis but where there is no record of it in the mother's family.

LOCATION, NAME OF INSTITUTION, AND PRINCIPAL COUNSELOR OF SOME OF THE HEREDITY CLINICS.

Location	Institution	Counselor
Berkely, California	University of Calfornia	Curt Stern
Salt Lake City, Utah	Laboratory of Human Genetics, University of Utah	F.E. Stephens
Austin, Texas	The Gentics Foundation University of Texas	C.P. Oliver
Normam, Oklahoma	University of Oklahoma	L.H. Snyder
Minneapolis, Minnesota	Dight Institute, University of Minnesota	S.C. Reed
New Orleans, Louisiana	Tulane University	H.W. Kloepfer
Ann Arbor, Michigan	Heredity Clinic, University of Michigan	J.V. Neel
Columbus, Ohio	Institute of Genetics, Ohio State University	D.C. Rife
Toronto, Ontario	Hospital of Sick Children	N.F. Walker
Winston-Salem, N. C.	Department of Medical Gentics, Bowman Gray School of Medicine	C.N. Herndon
Montreal, Quebec	Department of Medical Genetics, Children's Memorial Hospital	F.C. Fraser
New York, N. Y.	New York State Psychiatric Institute	F.J. Kallmann
Boston, Mass.	Children's Cancer Research Foundation, Harvard University	A.G. Steinberg

BIOLOGY 100-A

UNIT IX SCIENCE, SEX ... AND OTHER THINGS

OBJECTIVES FOR UNIT IX - SCIENCE, SEX ... AND OTHER THINGS

THE STUDENTS WILL BE ABLE TO DO THE FOLLOWING:

1. EXPLAIN WHAT IS MEANT BY ASEXUAL REPRODUCTION AND GIVE AN EXAMPLE OF AN ORGANISM THAT PRACTICES THIS PROCESS.
2. USE THE TERM, CLONE, IN AN EXPLANATION OF HOW IDENTICAL TWINS ARE FORMED.
3. DISCUSS THE RELATIONSHIP BETWEEN SEX AND GENETIC VARIABILITY AND RELATE THESE TO EVOLUTION.
4. EXPLAIN WHY OLD INDIVIDUALS ARE ELIMINATED.
5. TELL WHY A SPERM CELL IS DEPENDENT ON A NURSE CELL IN THE TESTIS.
6. RELATE THE FUNCTION OF THE TESTIS TO THE SITUATION WHERE IT DOES NOT DESCEND INTO THE SCROTUM.
7. IDENTIFY THE SITE OF FERTILIZATION IN HUMANS.
8. TRACE THE EARLY STAGES OF DEVELOPMENT OF THE EMBRYO.
9. EXPLAIN IN GENERAL TERMS THE STRUCTURE AND FUNCTION OF THE PLACENTA.
10. DISCUSS IN A GENERAL WAY, THE FEMALE HORMONAL CYCLE.
11. LIST AND DISCUSS THE FUNCTIONS OF SOME MODERN BIRTH-CONTROL DEVICES.
12. DEFINE THE "THALIDOMIDE SYNDROME".
13. EXPLAIN THE TWO "SHUNTS" THAT ARE PRESENT IN FETAL CIRCULATION AND WHICH DISAPPEAR SOON AFTER THE TIME OF BIRTH.
14. COMMENT ON THE EXPRESSION "AS SOON AS WE ARE BORN, WE START TO DIE".

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. IS THERE A DISTINCTION BETWEEN ABORTION AND BIRTH CONTROL?
2. KEEPING IN MIND DESMOND MORRIS' STATEMENT ABOUT MAN BEING THE SEXIEST PRIMATE, WHAT IS THE CORRELATION BETWEEN SEXINESS AND MORALS?
3. IS THE QUESTION CONCERNING EUTHANASIA (MERCY KILLING) PERTINENT TO THIS DISCUSSION?

UNIT IX - SCIENCE, SEX AND OTHER THINGS

Table I. Regulatory Hormones of the Menstrual Cycle. Understanding the role of these hormones has led to the development of certain contraceptive measures.

Hormone	Source	Effects
F.S.H. (follicle stimulating hormone)	Pituitary gland	1. Stimulates growth of one(?) follicle in ovary (thereby stimulating production of estrogen).
Estrogen	Follicle cells of follicle in ovary (and constant amount from other places)	1. Inhibits FSH production by pituitary. 2. Stimulates pituitary to produce luteinizing hormone. 3. Causes development of primary and secondary sex characteristics. 4. Esp. note: healing and proliferating of cells of lining of uterus (endometrium).
LH (luteinizing hormone)	Pituitary gland	1. Causes ovulation. 2. Changes scar of ovulate follicle into Corpus Luteum ("yellow body" in Latin).
Progesterone	Corpus Luteum (and some from other places)	1. Inhibits LH secretion by pituitary. 2. Causes further development of primary and secondary sex characteristics. 3. Causes differentiation of endometrium into glandular structure, ready for implantation. 4. Necessary for the maintenance of endometrium.
H.C.G. (Human Chorionic Gonadotrophin) (the "pregnancy hormone)	Placenta (chorion part)	1. Maintains endometrium and placenta even in the absence of progesterone.

BIOLOGY 100-A

UNIT X MORE ABOUT OTHER THINGS - HOW LARGE ORGANISMS ARE BUILT

OBJECTIVES FOR UNIT X - MORE ABOUT OTHER THINGS

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. DISCUSS THE PROCESS OF MITOSIS AND THE CELL CYCLE.
2. COMPARE THE HUMUNCULUS-TYPE PREFORMISM THEORY WITH EPIGENESIS.
3. DISCUSS THE RELATIONSHIP BETWEEN GENE ACTIVITY AND CELLULAR DIFFERENTIATION.
4. DEFINE ECTODERM, MESODERM, AND ENDODERM.
5. DISCUSS SOME WAYS IN WHICH PHYSICAL OR ENVIRONMENTAL FACTORS MAY EFFECT CELL DEVELOPMENT.
6. DISCUSS THE PROCESS OF INDUCTION AS IT APPLIES TO CELL DIFFERENTION.
7. GIVE PROS AND CONS FOR THE STATEMENT, "ONTOGENY RECAPITULATES PHYLOGENY".
8. GIVE THE BASIC ESSENTIALS FOR NORMAL EMBRYONIC DEVELOPMENT, AND DISCUSS THE VARIOUS MEANS BY WHICH DIFFERENT ANIMALS SOLVE THE PROBLEM OF OBTAINING THESE ESSENTIALS.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. AT WHAT POINT IN EMBRYOLOGICAL DEVELOPMENT DO YOU BELIEVE A FETUS BECOMES "HUMAN"?
2. ARE YOU FAMILIAR WITH CLONEING AND IF SO, SHOULD IT BE USED IN HUMANS?
3. IN WHAT CIRCUMSTANCES DO YOU THINK MEDICAL SCIENCE SHOULD BE ALLOWED TO TAMPER WITH HUMAN DEVELOPMENT?

Glossary For Unit X

Blastula - An early embryonic stage in animals, preceding the delimitation of the three principal tissue layers (ectoderm, mesoderm, and endoderm); usually a hollow sphere.

Ectoderm - Outer tissue layer of embryo; gives rise to skin and skin derivitives (hair, nails, sweat glands) and nervous system in the adult.

Endoderm - Inner tissue layer; gives rise to the lining of the digestive, respiratory, and urinary systems.

Epigenesis - The embryological view that an embryo develops by the progressive production of new parts that were nonexistent as such in the original zygote.

Gastrulation - The process of cell division and differentiation in which the embryo acquires its three tissue layers.

Mesoderm - Middle tissue layer; gives rise to skeleton, muscles, reproductive system, blood and blood vessels, lining of body cavities.

Neoteny - The retention of larval characters after the gonads have become sexually mature.

Ontogeny - The course of development of an individual organism.

Phylogeny - Evolutionary history of an organism.

Preformation - The idea that the young animal was preformed in the egg or sperm and development was an unfolding and growth of a miniature animal which could be seen in the germ cell.

BIOLOGY 100-A

UNIT XI CHANGES

OBJECTIVES FOR UNIT XI - CHANGES

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. LIST EXAMPLES OF IMMEDIATE PHYSIOLOGICAL CHANGE.
2. OUTLINE AT LEAST TWO LIFE CYCLES.
3. DEFINE THE CONCEPT OF EVOLUTIONARY CHANGE- THE HISTORY OF A SPECIES.
4. THE STUDENT WILL BE ABLE TO DEFINE THE FOLLOWING:
   - A. ECOLOGICAL NICHE
   - B. CIRCADIAN RHYTHMS
   - C. HUMAN CYCLES - GESTATION AND MENSTRUATION
   - D. LUNAR TIME
   - E. SEASONAL CHANGES
   - F. DEVELOPMENTAL CHANGES, SUCH AS: CRITICAL TIME AND IMPRINTING
   - G. BIOLOGICAL CLOCKS
   - H. GENOME
5. DISCUSS SPECIALIZED AND GENERALIZED LIFE CYCLES.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. WHAT ADVANTAGES DO BACTERIA HAVE IN NICHE EXPLOITATION?
2. WHAT ARE THE IMPLICATIONS OF DARWIN'S "SURVIVAL OF THE FITTEST"?
3. IN LIGHT OF THE SPECIES, WHY IS DEATH GOOD?
4. WHAT ARE THE STRENGTHS AND WEAKNESSES OF THE BACTERIAL LIFE CYCLE?
5. WHAT ARE THE STRENGTHS AND WEAKNESSES OF THE OYSTER LIFE CYCLE?
6. WHAT ARE THE STRENGTHS AND WEAKNESSES OF THE HUMAN LIFE CYCLE?
7. DISCUSS CRITICAL TIME AND ITS IMPLICATIONS IN LIGHT OF IMPRINTING AS SEEN IN YOUNG ANIMALS.

BIOLOGY 100-A

UNIT XII TERRESTRIALIZATION

OBJECTIVES FOR UNIT XII - TERRESTRIALIZATION

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

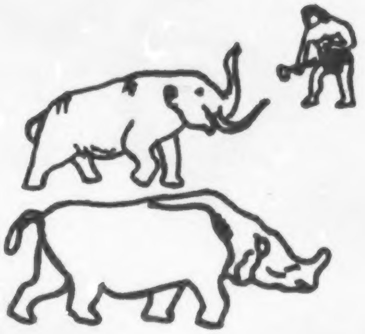
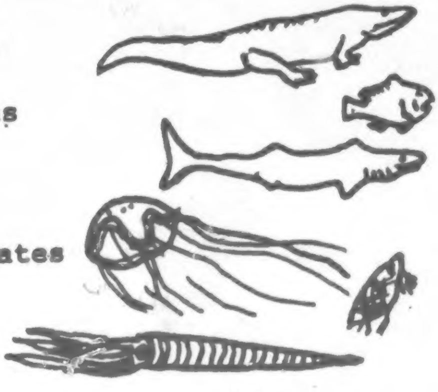
1. WHAT IS MEANT BY THE "FOSSIL RECORD".
2. KNOW THE ADVANTAGE TO THE PLANT OF BECOMING TERRESTRIALIZED (HIGHER LIGHT INTENSITY).
3. EXPLAIN CHANGES IN TISSUES OF LAND PLANTS TO FACILITATE:
   - A. LIQUID TRANSPORT
   - B. WATER CONSERVATION
   - C. EXCHANGE OF GASES
   - D. SUPPORT ON LAND
4. EXPLAIN CHANGES IN PLANT REPRODUCTION METHODS TO ACCOMODATE DRYER HABITATS.
5. UNDERSTAND SOME OF THE STRUCTURAL CHANGES REQUIRED OF ANIMALS IN ORDER THAT THEY BE ABLE TO SUCCESSFULLY MOVE AND COMPETE ON LAND. SUCH AS THE FOLLOWING:
   - A. THE DEVELOPMENT OF LIMBS
   - B. THE DEVELOPMENT OF AIR BREATHING ORGANS
   - C. SHIFT IN CIRCULATORY SYSTEMS
   - D. CHANGES IN METHODS OF REPRODUCTION
6. HAVE INSIGHTS RELATIVE TO THE COMPLEX CHANGES REQUIRED FOR LIFE ON LAND.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. DIFFERENCE IN PHOTOSYNTHESIS OF WATER DWELLING PLANTS VS. LAND PLANTS.
2. REPRODUCTION AS COMPETITION AMONG LAND PLANTS.
3. REPRODUCTION AS COMPETITION AMONG LAND ANIMALS.
4. WHAT WOULD LIFE BE LIKE IF TERRESTRIALIZATION HAD NOT OCCURED?
5. COMPARE A FISH'S GILL WITH A MAMMAL'S LUNG.
6. COMPARE A FISH'S PECTORAL FIN TO A DOG'S FORELEG.
7. COMPARE A FISH'S EGG TO A BIRD'S EGG.
8. COMPARE A BIRD'S EGG TO A MAMMAL'S PLACENTAL DEVELOPMENT.
9. COMPARE A FERN SEXUAL REPRODUCTIVE CYCLE TO THAT OF A FLOWERING PLANT.
10. DISCUSS WATER CONSERVATION IN HIGHER PLANTS.

Table I. The Geologic Time Scale. - Unit XII

ERA	PERIOD	MILLIONS OF YEARS	ENVIRONMENT
Cenozoic "new life"	Quarternary	0-1	Four ice ages; climate warms after last one
	Tertiary	1-63	Continent building; climate gets colder
Mesozoic "middle life"	Cretaceous	63-135	Inland swamps common; rise of the Rockies
	Jurassic	135-181	Continents high and small, much of present area submerged; mild climates
	Triassic	181-230	Great deserts; arid climates
Paleozoic "ancient life"	Permian	230-280	Rise of mountains glaciers and deserts common; extremes of climate
	Carboniferous	280-345	Warm and humid; coal deposits formed
	Devonian	345-425	Inland seas grow smallar;many coral reefs;firstanimals on land
	Silurian	425-435	Large land areas with inland seas first land plants
	Ordovician	435-500	Land extensively submerged; climate very warm
	Cambrian	500-600	Lands very low; moderate upheavals; climates mild
Pre-cambrian		600-(?)	Extremely violent conditions; unstable atmosphere

ERA	DOMINANT ANIMAL LIFE	DOMINANT PLANT LIFE
Cenozoic "new life" Mammals		Flowers
Mesozoic "middle life" Reptiles		Gymnosperms Cycads
Paleozoic "ancient life" Amphibians Fishes Invertebrates		Early Vascular Plants Algae
Pre-cambrian	First	Life

Activity I - The Movement of Water in Terrestrial Plants -Unit XII

The water and minerals required by higher plants for photosynthesis and other metabolic processes is absorbed from the soil and moves upward to all the cells of the plant. The photosynthetic product made in the leaf dissolves in cellular water and is moved or translocated to all the cells of the plant which are incapable of manufacturing their own food. The tubes for conduction are collectively called vascular systems. Openings in leaves, usually on the under surface, return most of the water not used by the plant back to the atmosphere as water vapor in a process termed transpiration.

A. Demonstration of Transpiration

A green plant sealed under a bell jar has been placed on display at rhe Experimental Table. A second apparatus, similarly sealed, but containing no plant is also demonstrated. Compare the two jars. Record your observations below.

B. Some Factors Which Govern Movement of Water in Plants

The amount of water moving through a green plant can be measured using a potometer which in this case is simply a calibrated tube attached and sealed to the cut end of a plant stem.

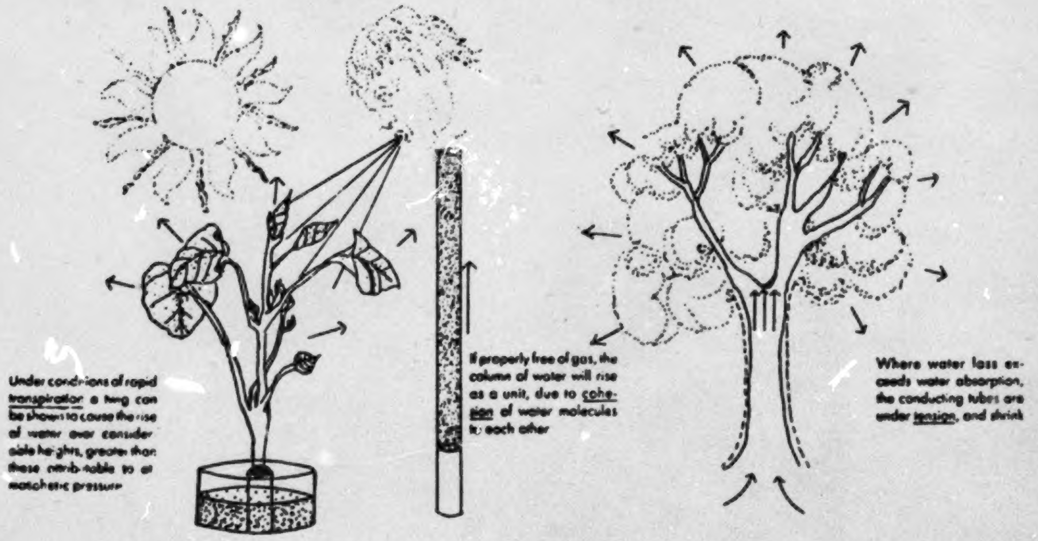
Observe the various experimental conditions and note the relative rates of transpiration.

Go to slide 17 and start tape.

The Force

Several forces working together account for the rise of water in plants:

1. Root pressure caused by diffusion of water molecules from soil into root hairs and roots (osmosis) and,
2. Transpiration pull caused by evaporation of water from leaves, osmosis and cohesion of water molecules as shown in the diagram: (From Galston, The Life of the Green Plant, Prentice-Hall, Inc., 1961)



Under conditions of rapid transpiration a lung can be shown to cause the rise of water over considerable heights, greater than those attributable to atmospheric pressure

If properly free of gas, the column of water will rise as a unit, due to cohesion of water molecules to each other

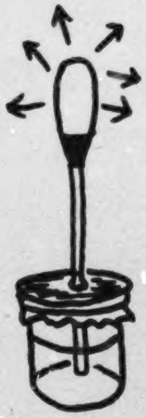
Where water loss exceeds water absorption, the conducting tubes are under tension, and shrink

The amount of water used by a plant for photosynthesis and all other metabolic functions is only about five percent of the total amount taken in. The other ninety-five percent is lost by evaporation (=transpiration) through the stomatal openings. This large amount of water loss is not the result of poor construction, rather, it is necessary if water is to be continuously transported upstem.

The following data are taken from an experiment designed to compare transpiration from leaves with the evaporation of water from a non-living surface. The amount of water lost per hour by transpiration from 100 square centimeters of leaf area during a 24 hour period was carefully determined, and compared to the amount lost by evaporation from 100 square centimeters of a cup atmometer.

A cup atmometer is made of porous clay; when filled with water it duplicates as nearly as possible conditions in the leaf, except those involved in its life processes.

100 square cm.
leaf surface



100 square cm.
porous surface

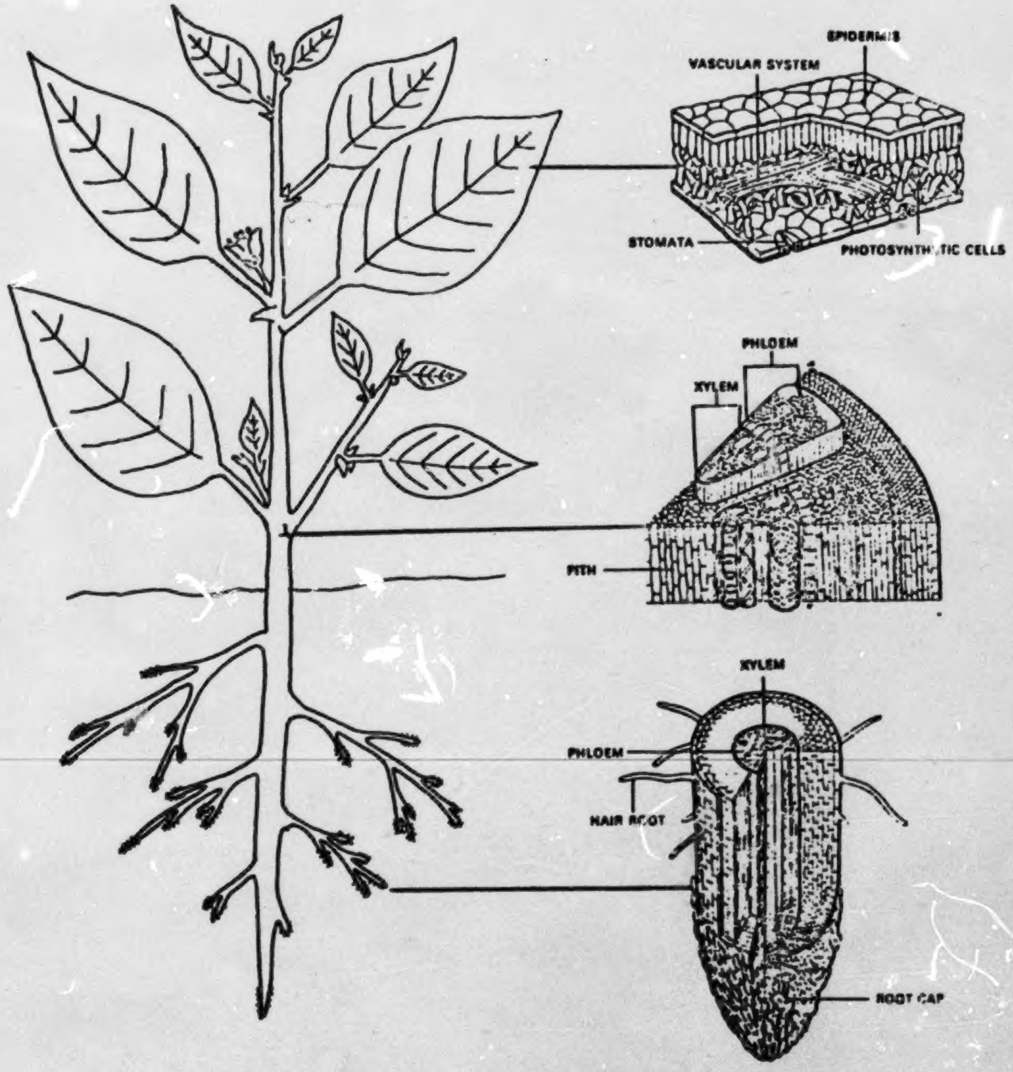
Grams of Water Lost Time	Transpiration from leaves	Evaporation from cup
12 midnight	0.09	0.41
1 AM	0.09	0.35
2 AM	0.09	0.35
3 AM	0.09	0.37
4 AM	0.09	0.41
5 AM	0.18	0.35
6 AM	0.18	0.35
7 AM	0.31	0.35
8 AM	0.43	0.50
9 AM	0.47	0.91
10 AM	1.57	0.97
11 AM	1.96	1.20
12 Noon	2.15	2.25
1 PM	2.55	2.34
2 PM	2.74	2.04
3 PM	1.70	1.95
4 PM	0.82	1.20
5 PM	0.22	0.71
6 PM	0.08	0.55
7 PM	0.08	0.44
8 PM	0.08	0.35
9 PM	0.08	0.35
10 PM	0.08	0.35
11 PM	0.08	0.35

How could you interpret the above figures?
Go to slide 21 and start tape.

Activity III - How Plants Solve Their Water Problems - Unit XII

A. Although many plants have escaped their watery ancestral home, they never really emancipated themselves from water. They need water to begin life - seed germination - and they need it incessantly until they die. Where there is no water, there are no plants.

In the diagram below, observe how the flowering plant has solved the problem which allows for a dry-land existence by indicating what each structure contributes to the solution.



Go to slide 28 and start tape.

Activity IV - Toward a New Environment - Unit XII

In the case of the conquest of land, plants and animals have moved out of their aquatic environment and migrated to a new, virgin one. Probably the first steps were effected in tidal regions or in damp bogs but through these transitional areas there eventually was a real transfer to land. With this transfer came a new series of problems. In the table below, summarize the provisions which pertained in each situation listed:

The Life Condition	Aquatic Organisms	Terrestrial Plants	Terrestrial Animals
Support			
Locomotion			
Prevention of Desiccation			
Gaseous exchange			
Reproduction			
Maintaining Cellular Water			

Activity V - Some Animal Adaptations to Terrestrial Existence - Unit XII

Many complex problems confronted animals as they made the transition from water to land life. Two of these we will consider in this laboratory - support systems and breathing problems.

A. Primitive land animals resembled their fishy ancestors with elongated bodies and tails. The most striking contrast between the early amphibians and their fish ancestors is seen in the limbs. The paired fins of ancestral fish have been transformed into land limbs. As new environments were invaded, considerable reorganization of the skeleton has occurred to fit the organisms more efficiently to their new environments. In this lab we will examine modification of the pelvic bones in several forms from the standpoint of adaptation.

1. Examine the bones which make up the pelvic (hip) and the pectoral girdle (forelimbs) of a frog, rabbit and human, noting their relative size, fusion of bones and thickness of each.

2. Using your observations, fill in the following chart:

Organism	Distribution of total body weight	Adaptation of pelvis	Major function of the pelvic girdle	Pectoral girdle
Frog				
Rabbit				
Human				

Go to slide 40 and start tape.

BIOLOGY 100-A

UNIT XIII HOMEOSTASIS AND CYBERNETICS IN ANIMALS

OBJECTIVES FOR UNIT XIII - HOMEOSTASIS AND CYBERNETICS IN ANIMALS

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. GIVE A CONCISE DEFINITION OF HOMEOSTASIS.
2. COMPARE AND CONTRAST LIFE AND NON-LIFE IN TERMS OF HOMEOSTATIC CONTROL MECHANISMS.
3. GIVE AN EXAMPLE, WITH A DIAGRAM, OF A HUMAN HOMEOSTATIC MECHANISM.
4. GIVE AN EXAMPLE, WITH A DIAGRAM, OF A NON-LIVING CYBERNETIC SYSTEM.
5. DEFINE HOMEOTHERM AND POIKILOTHERM AND EXPLAIN THEIR ECOLOGICAL SIGNIFICANCE.
6. DISCUSS THE VARIOUS MEANS OF MAINTAINING A CONSTANT BODY TEMPERATURE IN HOMEOTHERMS.
7. DISCUSS THE PHYSIOLOGY OF THE HUNGER "DRIVE" WITH EMPHASIS ON THE ROLE OF THE HYPOTHALAMUS, BLOOD SUGAR LEVEL, THE HORMONES INVOLVED, AND PSYCHOLOGICAL FACTORS.
8. DISCUSS THE HOMEOSTATIC CONTROL OF BODY FLUID BALANCE WITH AN EMPHASIS ON HORMONE AND NERVOUS INFLUENCES.
9. DEFINE DIABETES INSIPIDUS.
10. DEFINE HORMONES.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. HOW DOES MEDICAL TECHNOLOGY RELATE TO HOMEOSTASIS IN MAN?
2. IN RELATION TO THE GYPOTHALAMUS, CAN YOU THINK OF ANY WAY MAN COULD ALTER THIS HOMEOSTATIC MECHANISM?
3. THE NERVOUS AND ENDOCRINE SYSTMES ARE SOMETIMES CALLED COLLECTIVELY THE NEUROENDOCRINE SYSTEM. WHAT IS THE REASONING BEHIND THIS?

Glossary For Unit XIII

Cybernetics - The study of autonomous control, or negative-feedback systems.

Endocrine Glands - Ductless glands which produce hormones and secrete them directly into the blood. Examples: pituitary gland, thyroid gland, adrenal glands, etc.

Homeostasis - The tendency in an organism to maintain a constant internal environment.

Homeothermic - Referring to animals which maintain a relatively constant body temperature.

Hormone - A control chemical secreted in one part of the body and carried by the blood to other parts of the body where it exerts its effects.

Poikilothermic - Referring to animals whose body temperature fluctuates with the environmental temperature.

BIOLOGY 100-A

UNIT XIV CYBERNETICS AND HOMEOSTASIS IN PLANTS AND CELLS

OBJECTIVES FOR UNIT XIV - CYBERNETICS AND HOMEOSTASIS IN PLANTS AND CELLS

THE STUDENT WILL BE ABLE TO DO THE FOLLOWING:

1. DEFINE TROPISM AND DISCUSS THE ADAPTIVE VALUE OF THESE RESPONSES.
2. DISCUSS THE DIFFERENCE IN RATE OF PLANT AND ANIMAL RESPONSES TO THE ENVIRONMENT.
3. GIVE THE TWO MAJOR CLASSES OF PLANT HORMONES AND BRIEFLY DISCUSS THEIR SIMILARITIES AND DIFFERENCES.
4. DISCUSS HOW MAN HAS USED HIS KNOWLEDGE OF PLANT HORMONES TO HIS ADVANTAGE.
5. DISCUSS THE ADVANTAGE OF CHEMICAL INHIBITION OF SEED GERMINATION IN DESERT PLANTS.
6. DEFINE "LONG DAY" AND "SHORT DAY" PLANTS AND DISCUSS THE ROLE OF THE HORMONE FLORIGEN IN THIS PHENOMENON.
7. DEFINE AUTOTROPHIC.
8. DISCUSS THE MEANS BY WHICH A CELL CAN CONTROL THE PRODUCTION OF ITS PRODUCTS.
9. DISCUSS REGULATORY, OPERATOR, AND STRUCTURAL GENES AND THEIR ROLE IN ENZYME PRODUCTION.
10. COMPARE BEHAVIORAL RESPONSES OF ANIMALS TO A COMPUTER.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. DO YOU THINK MAN EXIBITS ANY TROPISTIC RESPONSES? IF NOT CAN YOU NAME OTHER ANIMALS THAT DO?
2. CAN YOU NAME ANY HUMAN HORMONES THAT HAVE EFFECTS SIMILAR TO PLANT HORMONES?
3. IS MAN'S BEHAVIOR REALLY MACHINE-LIKE?

Glossary For Unit XIV

Apical dominance - Tendency for the apical bud to inhibit the growth of lateral buds.

Autotrophic - Capable of manufacturing organic nutrients (food) from inorganic raw materials.

Auxin - Any one of a class of plant hormones that promote cell elongation and can diffuse into a decapitated plant from an agar block, causing it to bend in the dark (Went test).

Gibberellin - A plant hormone, one effect of this is stem elongation in some plants.

Photoperiodism. - A response by an organism to the duration and timing of the light and dark conditions.

Tropism - A turning response to a stimulus; may be positive, i.e. toward the stimulus, or negative, i.e. away from the stimulus. Examples: geotropism (response to gravity) and phototropism (response to light).

BIOLOGY 100-A

UNIT XV The Meaning of Biology to Modern Man

OBJECTIVES FOR UNIT XV - THE MEANING OF BIOLOGY TO MODERN MAN

THE OBJECTIVES FOR THIS UNIT DIFFER WHEN COMPARED WITH THE OBJECTIVES OF PREVIOUS UNITS. HERE WE ARE NOT SO CONCERNED WITH ACQUIRING VERY SPECIFIC FACTS OR DETAILS ABOUT BIOLOGICAL ORGANISMS OR SYSTEMS, BUT ARE CONCERNED, AT LEAST IN ONE SENSE, WITH THE BIOLOGICAL FUTURE OF MAN. IN THIS LIGHT, THREE OBJECTIVES ARE EMPHASIZED. THEY ARE:

1. TO INTRODUCE THE IDEA OF SURVIVAL AS THE GOAL OF MAN S IMMEDIATE FUTURE AND TO INTRODUCE TWO BIOLOGICAL LAWS OF SURVIVAL.
2. TO RE-EMPHASIZE THE LIMITS OF ENERGY USE; TO SUGGEST ROLES THAT THE INDIVIDUAL, GOVERNMENT, AND TECHNOLOGY WILL HAVE TO PLAY IN ORDER TO BRING ABOUT CHANGE.
3. TO PROVIDE THE STUDENT A LIST OF QUESTIONS TO CONSIDER IN RELATIONSHIP TO THE MEANING OF BIOLOGY TO MODERN MAN. IT IS NOT NECESSARY THAT YOU ATTEMPT TO PROVIDE SIMPLE ANSWERS TO THESE QUESTIONS AT THE PRESENT TIME, BUT, MORE IMPORTANTLY, TO THINK ABOUT THESE QUESTIONS IN THE LIGHT OF WHAT HAS BEEN PRESENTED IN THIS TERM'S WORK. A GOOD IDEA WOULD BE TO SELECT TWO OR THREE OF THESE AND USE IN YOUR SMALL-GROUP DISCUSSION FOR THIS WEEK. QUESTIONS 1, 3, AND 10 WOULD BE PARTICULARLY USEFUL TO DISCUSS IN A GROUP.

TOPICS FOR DISCUSSION IN SEMINAR GROUPS

1. HOW HAS NEW INFORMATION IN BIOLOGY CONTRIBUTED TO A RETHINKING OF PUBLIC OPINIONS AND ATTITUDES?
2. HOW HAVE THE FINDINGS OF BIOLOGY MADE MODERN MAN MORE AWARE OF HIMSELF AND HIS ENVIRONMENT?
3. HOW IS MODERN BIOLOGY CHANGING MAN AND HIS SOCIETY?
4. WHAT NEW PROBLEMS HAVE RESULTED FROM BIOLOGICAL DISCOVERIES AS THEY ARE APPLIED TO TECHNOLOGY?
5. IS BIOLOGY A "TWO-EDGED SWORD"?
6. SHOULD A MORATORIUM BE DECLARED ON NEW BIOLOGICAL DISCOVERIES TO ALLOW SOCIETY A "CHANCE TO CATCH UP" AS SOME HAVE SUGGESTED?
7. WHY SHOULD THE INFORMED CITIZEN BE CONCERNED?
8. HOW CAN HE BE INVOLVED?
9. WHAT ROLE SHOULD THE GOVERNMENT PLAY IN THE UTILIZATION, SUPPORT AND/OR CONTROL OF NEW BIOLOGICAL DISCOVERIES?
10. ARE THERE LIMITS TO WHAT BIOLOGISTS SHOULD BE ALLOWED TO DO?